Colorectal Cancer: Screening Double-Contrast Barium Enema Examination in Average-Risk Adults Older Than 50 Years[1]

Justin W. Kung, MD
Marc S. Levine, MD
Seth N. Glick, MD
Paras Lakhani, MD
Stephen E. Rubesin, MD
Igor Laufer, MD

Purpose: To retrospectively determine the diagnostic yield of double-contrast barium enema examinations performed for colorectal cancer screening of neoplasms 1 cm or larger or advanced neoplastic lesions of any size in average-risk adults older than 50 years.

Materials and Methods: The Institutional Review Board at the affiliated Veterans Affairs Medical Center approved this HIPAA-compliant study protocol and did not require informed consent from patients. Computerized databases revealed 276 double-contrast barium enema examinations performed for colorectal cancer screening in average-risk adults older than 50 years. Radiographic and pathologic reports were reviewed to determine the number of patients who had polypoid lesions 1 cm or larger, polyps smaller than 1 cm, or advanced neoplastic lesions of any size. Forty-five (16.3%) of the 276 patients underwent follow-up sigmoidoscopy or colonoscopy. Medical, endoscopic, and pathologic records were reviewed and compared with radiographic findings.

Results: The results of double-contrast barium enema examination revealed 74 (26.8%) of 276 patients with 104 polypoid lesions in the colon, including 32 patients (11.6%) with 41 polypoid lesions 1 cm or larger, 15 patients (5.4%) with 19 polyps 6–9 mm, and 27 patients (9.8%) with 44 polyps 5 mm or smaller. Endoscopy was performed in 24 (75%) of 32 patients, the results of which confirmed 23 (72%) of 32 radiographically diagnosed lesions 1 cm or larger in 16 (67%) of 24 patients. In two of these individuals, the polyps were hyperplastic. The remaining 14 patients had a total of 21 neoplastic lesions 1 cm or larger, including 11 tubular adenomas, seven tubulovillous adenomas, one villous adenoma with marked dysplasia, and two cancers. The diagnostic yield of screening double-contrast barium enema examination was 5.1% (14 of 276 patients) for neoplastic lesions 1 cm or larger and 6.2% (17 of 276 patients) for advanced neoplastic lesions of any size.

Conclusion: Double-contrast barium enema examinations performed in average-risk adults older than 50 years have a diagnostic yield of 5.1% for neoplastic lesions 1 cm or larger and 6.2% for advanced neoplastic lesions, regardless of size.

[1] From the Department of Radiology, Hospital of the University of Pennsylvania, 3400 Spruce St, Philadelphia, PA 19104 (J.W.K., M.S.L., S.N.G., P.L., S.E.R., I.L.); and Department of Medical Imaging, Presbyterian Medical Center, Philadelphia, Pa (S.N.G.). Received July 22, 2005; revision requested September 20; revision received October 15; accepted November 16; final version accepted December 16. **Address correspondence to** M.S.L. (e-mail: *marc.levine@uphs.upenn.edu*).

Colorectal cancer is the second leading cause of cancer-related death in the United States; it occurs in approximately 150 000 people and accounts for more than 56 000 deaths each year (1). The majority of colorectal cancers develop from preexisting adenomatous polyps that undergo malignant degeneration by means of a well-documented adenoma-carcinoma sequence (2–5). It has also been shown that colorectal cancer screening with sigmoidoscopy or fecal occult blood testing reduces mortality by 30%–33% (6,7).

Because one-half of colonic adenomas are located proximal to the rectosigmoid colon and one-third are located proximal to the splenic flexure (8,9), advocates of colorectal cancer screening have increasingly emphasized the benefit of a total colon examination—primarily colonoscopy—for the detection of adenomatous polyps beyond the reach of sigmoidoscopy (10). The risk of cancer in these individuals is directly related to polyp size; fewer than 1% of polyps smaller than 1 cm are found to be malignant compared with 10% or more of polyps 1 cm or larger (2,3). Colonoscopy has been shown to be a sensitive technique for the detection of larger adenomatous polyps (10) and allows polyps to be removed at the time of the initial examination, without the need for a second procedure.

Advances in Knowledge

- Screening double-contrast barium enema examinations in average-risk adults who are older than 50 years have a diagnostic yield of 6.2% for advanced colorectal neoplasms (ie, adenomas 1 cm or larger or any lesions containing villous features, high-grade dysplasia, or invasive carcinoma, regardless of size), which is within the lower range of what has been reported for colonoscopy.
- Our findings suggest that double-contrast barium enema examinations can have a greater role in colorectal cancer screening.

On the other hand, more than 90% of average-risk adults who are older than 50 years do not have colonic adenomas that are 1 cm or larger (11). Thus, most individuals who undergo screening with colonoscopy do not have clinically important neoplasms but will undergo an invasive procedure that requires sedation and is associated with a perforation rate of 1 per 1000 examinations compared with 1–2 per 10 000 examinations for sigmoidoscopy and 1 per 25 000 examinations for barium enema studies (10). In the past 5 years, computed tomographic (CT) colonography has also been advocated as a noninvasive alternative to colonoscopy, with considerable potential for colorectal cancer screening (12).

In 1997, the American Cancer Society and other medical organizations formally endorsed a new set of clinical guidelines for colorectal cancer screening that included double-contrast barium enema examinations as an option for screening in average-risk adults older than 50 years (10). Six years later, the guidelines of the American Cancer Society were revised to include a recommendation that patients undergo a screening double-contrast barium enema examination every 5 years (13). Double-contrast barium enema examinations have also been approved as a reimbursable option for colorectal cancer screening in both average-risk and high-risk individuals under Medicare guidelines (14). The value of performing a screening double-contrast barium enema examination is supported by cost-effectiveness models, which show that undergoing double-contrast barium enema examinations at 5-year intervals is competitive with other strategies for colorectal cancer screening (15–17).

Despite a number of convincing arguments for the increasing use of double-contrast barium enema examinations as a primary screening tool for colorectal cancer (18), this technique has been largely overlooked by proponents of screening. To our knowledge, no studies to date have evaluated the diagnostic yield of performing a double-contrast barium enema examination for colorectal cancer screening in average-risk adults who are older than 50 years. Because double-contrast barium enema examinations are frequently performed at our affiliated Veterans Affairs Medical Center as a primary screening test for colorectal cancer, we had the opportunity to obtain follow-up data from a relatively large number of patients who underwent this procedure. The purpose of our study, therefore, was to retrospectively determine the diagnostic yield of double-contrast barium enema examinations performed for colorectal cancer screening of neoplasms 1 cm or larger or advanced neoplastic lesions of any size in average-risk adults older than 50 years.

Materials and Methods

Institutional Review Board Approval and Potential Conflicts of Interest

The Institutional Review Board of our affiliated Veterans Affairs Medical Center approved all aspects of our Health Insurance Portability and Accountability Act–compliant study protocol and did not require informed consent from any of the patients whose radiographic studies and medical records were used. Two authors (M.S.L. and S.E.R.) are consultants for E-Z-Em (Westbury, NY), which manufactures the barium that was used for the double-contrast barium enema examinations. However, two other authors (J.W.K. and P.L.), who are not employees of or consultants for E-Z-Em, had control of all data included in this study to avoid any potential conflicts of interest.

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Guarantor of integrity of entire study, M.S.L.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; manuscript final version approval, all authors; literature research, J.W.K., M.S.L., S.N.G.; clinical studies, M.S.L., S.E.R., I.L.; and manuscript editing, all authors

See Materials and Methods for pertinent disclosures.

Patient Population

A review of the computerized radiology database at our Veterans Affairs Medical Center by one author (J.W.K.) revealed that 1751 double-contrast barium enema examinations had been performed during a 3-year period from March 2000 to May 2003. Subsequent review of a computerized medical database by two authors (J.W.K. and P.L., working independently) revealed that 276 (15.8%) of these 1751 double-contrast barium enema examinations were performed for colorectal cancer screening in asymptomatic average-risk adults who were older than 50 years.

As in the previous literature, average-risk patients were defined as those who had no history of colorectal adenomas, no personal or family history (ie, first-degree relatives) of colorectal cancer, and no history of ulcerative colitis or a polyposis syndrome (10). Patients with gastrointestinal symptoms, such as rectal bleeding, altered bowel habits, or abdominal pain, were excluded from the study; however, those with unrelated medical problems, such as cardiac or pulmonary disease, diabetes, or psychiatric disorders, were included.

A total of 276 patients were included in our study group, which had a mean age of 59.4 years (range, 51–80 years). When grouped according to decades, 157 patients (56.9%) were 50–59 years old, 85 (30.8%) were 60–69 years old, 33 (12.0%) were 70–79 years old, and one (0.4%) was 80–89 years old. Two hundred sixty-nine patients (97.5%) were men and seven (2.5%) were women.

Examination Technique

All patients who underwent screening barium enema examination received a standard bowel cleansing preparation that consisted of clear liquids for 24 hours prior to the examination and oral administration of 10 oz (296 mL) of magnesium citrate, which was followed by three bisacodyl tablets the evening before the examination. At the outset of the procedure, these individuals received a standard intravenous dose of 1 mg of glucagon to induce colonic hypotonia. Double-contrast barium enema examinations were performed by using a 100% wt/vol barium suspension (Liquid Polibar Plus; E-Z-Em) that was administered through an enema tip inserted into the rectum.

Examinations consisted of the acquisition of multiple fluoroscopic spot radiographs of the rectum, sigmoid colon, cecum, and splenic and hepatic flexures, as well as a series of overhead radiographs (including a prone view, prone-angled view, supine and oblique views, and left and right lateral decubitus views of the colon and a prone cross-table lateral view of the rectum), as previously described (19). All studies were obtained with conventional fluoroscopic equipment (400-speed RFXII; GE Medical Systems, Waukesha, Wis). The examinations were performed by supervised radiology residents or by one of three attending gastrointestinal radiologists (M.S.L., S.E.R., and I.L., with 18, 16, and 24 years of experience in gastrointestinal radiology, respectively, as of March 2000), and all examination results were interpreted by the attending radiologists.

Data Collection

Radiologic, endoscopic, and pathologic reports for patients who had undergone screening double-contrast barium enema examinations were reviewed by two authors (J.W.K. and P.L., working independently) to determine *(a)* the number of patients with polypoid lesions (the largest of which was 1 cm or larger), *(b)* the number of patients with polyps (the largest of which was smaller than 1 cm), and *(c)* the number of patients with advanced neoplastic lesions of any size. As in previous studies, advanced neoplastic lesions in the colon were defined as adenomas that had a diameter of 1 cm or larger or as any lesion that contained villous features, high-grade dysplasia, or invasive carcinoma, regardless of size (20–22).

The number of lesions, as well as the size and location of each lesion described in the original radiologic reports, was recorded. The polyps generally were measured at the time of the screening examination, without correcting for magnification. On the basis of the measurements given in the original reports, polyps were placed in one of two size groups: those 1 cm or larger and those smaller than 1 cm. Polyps smaller than 1 cm were further stratified according to size (6–9 mm or ≤5 mm). Any adverse reactions or complications that occurred during the barium enema examination were also recorded.

Two authors (M.S.L. and S.N.G., with 18 and 21 years of experience in gastrointestinal radiology, respectively, as of March 2000) retrospectively reviewed the results of all barium enema examinations for patients who had undergone endoscopic follow-up and who were reported to have neoplastic lesions 1 cm or larger. Without knowledge of the endoscopic findings, these authors assigned, in consensus, a confidence level (high, moderate, or low) for the presence of each lesion that was described in the radiologic report. For the purposes of this review, a high confidence level indicated that the reviewers were extremely confident that the lesions reported during the barium enema examination were true-positive findings, a moderate confidence level indicated that the reviewers had some doubts as to whether the lesions were true-positive findings, and a low confidence level indicated that the reviewers believed the lesions were probably false-positive findings related to the presence of adherent stool or other artifacts.

To validate the original measurements, the same two authors also remeasured all polypoid lesions that measured 1 cm or larger for which endoscopic follow-up results were available. Lesions were measured on either spot radiographs or overhead radiographs, depending on which images best showed the lesions.

A review of the computerized medical records revealed that 45 (16.3%) of the 276 patients who underwent screening double-contrast barium enema examination also underwent follow-up colonoscopy ($n = 32$) or sigmoidoscopy ($n = 13$) because of radiographically diagnosed colorectal polyps, including 24 patients in whom the largest reported lesion was 1 cm or larger and 21 pa-

tients in whom the largest reported lesion was smaller than 1 cm. The mean interval between double-contrast barium enema examination and endoscopy was 7 months (range, 1–24 months).

Another 52 (18.8%) of 276 patients without colorectal polyps detected during screening double-contrast barium enema examination underwent follow-up sigmoidoscopy (n = 51) or colonoscopy (n = 1). Because the results of previous studies have shown that sigmoidoscopy combined with double-contrast barium enema examination improves the detection of neoplastic lesions in the sigmoid colon (23), sigmoidoscopy was performed in 51 (25.2%) of the 202 patients who had negative screening barium enema results. The mean interval between the double-contrast barium enema examination and endoscopy was 7.7 months (range, 0–31.5 months).

Results

Seventy-four (26.8%) of the 276 patients who underwent screening double-contrast barium enema examination had 104 polypoid lesions detected in the colon, including 32 patients (11.6%) with 41 polypoid lesions that were 1 cm or larger (with or without additional polyps smaller than 1 cm) (Figs 1–4) and 42 patients (15.2%) with 63 polyps that were smaller than 1 cm (including 15 patients [5.4%] with 19 polyps that were 6–9 mm and 27 patients [9.8%] with 44 polyps that were 5 mm or smaller) (Table 1). The remaining 202 patients (73.2%) had no polyps detected during double-contrast barium enema examination.

Follow-up colonoscopy (n = 32) or sigmoidoscopy (n = 13) was performed in 45 (61%) of 74 patients who had radiographically diagnosed polyps of any size.

Polypoid Lesions Measuring 1 cm or Larger

Twenty-four (75%) of the 32 patients with polypoid lesions 1 cm or larger at double-contrast barium enema examination underwent follow-up sigmoidoscopy (n = 4) or colonoscopy (n = 20) (Table 2). These 24 patients had 32 polypoid lesions that were 1 cm or larger at double-contrast barium enema examination. Endoscopic results confirmed the presence of 23 (72%) of the 32 radiographically diagnosed lesions in 16 (67%) of these 24 patients (12 had one lesion at endoscopy, two had two lesions at endoscopy, one had three lesions at endoscopy, and one had four lesions at endoscopy). For the double-contrast barium enema examination, the mean diameter reported for the 23 confirmed polypoid lesions that measured 1 cm or larger was 1.6 cm (range, 1–5 cm). During retrospective review of the images, our confidence level for the presence of a lesion was high for 17 (74%) of the 23 lesions, moderate for five lesions (22%), and low for one lesion (4%).

Of the 24 patients who underwent follow-up endoscopy, the remaining eight (33%) had nine polypoid lesions measuring 1 cm or larger at double-contrast barium enema examination (seven patients had one lesion and one patient had two lesions) that were not seen at

Figure 1

Figure 1: Cecal polyp in 69-year-old man. Close-up view of left lateral decubitus radiograph from screening double-contrast barium enema examination shows smooth sessile 1.2-cm polyp (arrow) arising from superior lip of ileocecal valve. Resected polyp was a tubular adenoma.

Figure 2

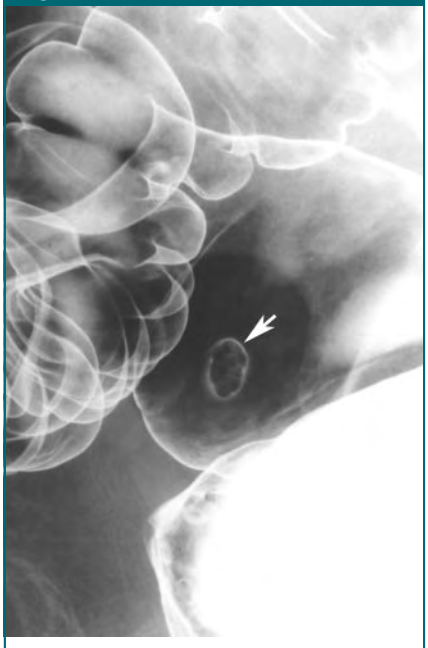

Figure 2: Sigmoid polyp in 63-year-old man. Steep right posterior oblique spot radiograph from screening double-contrast barium enema examination shows slightly lobulated 1.5-cm polyp (arrow) in proximal rectum. Resected polyp was a tubulovillous adenoma.

Figure 3

Figure 3: Two sigmoid polyps in 57-year-old man. Frontal spot radiograph from screening double-contrast barium enema examination shows a sessile 2-cm polyp (black arrow) and a pedunculated 2.3-cm polyp in sigmoid colon. Note how the pedunculated polyp produces a Mexican hat sign, with the outer white ring (white arrow) representing head of polyp and the inner white ring (arrowhead) representing the stalk seen through the head. Resected polyps were tubulovillous adenomas with mild dysplasia.

Table 1

Number and Size of True-Positive and False-Positive Polypoid Lesions in 74 Patients with Positive Results Obtained at Double-Contrast Barium Enema Examination

Polyp Size (cm)	No. of Patients (n = 74)	No. of Lesions Detected		True-Positive Lesions (n = 42)	False-Positive Lesions (n = 23)
		Barium Enema Examination	Follow-up Endoscopy		
≥1	32 (11.6)*	41	32	23 (80)	9 (29)
<1	42 (5.4)*	63	33	19 (58)	14 (42)

Note.—Data in parentheses are percentages.

* Percentages were calculated out of 276 patients.

colonoscopy (n = 5) or sigmoidoscopy (n = 3). Thus, these nine lesions were considered to be false-positive radiographic findings (Table 2). For the double-contrast barium enema examination, the mean diameter reported for the nine false-positive lesions was 1.2 cm (range, 1.0–2.2 cm). During retrospective review of the images, however, our confidence level for the presence of a lesion was high for only three (33%) of nine lesions, moderate for two lesions (22%), and low for four lesions (44%). It was also noted in one endoscopic report that the preparation was poor, so this patient may have had a false-negative endoscopic result rather than a false-positive barium enema result.

In one of the 24 patients with radiographically diagnosed lesions 1 cm or larger, colonoscopy revealed an additional polypoid lesion larger than 1 cm (1.5 cm) that was not detected at double-contrast barium enema examination. This individual, however, had two other lesions that measured 1 cm or larger at double-contrast barium enema examination (both confirmed with endoscopy). Thus, colonoscopy had been recommended despite our failure to detect the third lesion. None of the remaining 23 patients had polypoid lesions 1 cm or larger at endoscopy that were missed at double-contrast barium enema examination.

The 16 patients with 23 confirmed polypoid lesions measuring 1 cm or larger at double-contrast barium enema examination all underwent endoscopic (n = 14) or surgical (n = 2) removal of the lesions. In two of these individuals, the lesions (both 1 cm in size) were found to be hyperplastic polyps. The remaining 14 patients had a total of 21 neoplastic lesions 1 cm or larger, including 11 tubular adenomas (with mild dysplasia in five lesions and moderate dysplasia in one lesion) (Fig 1), seven tubulovillous adenomas (with mild dysplasia in three lesions and moderate dysplasia in one lesion) (Figs 2 and 3), one villous adenoma with marked dysplasia, and two adenocarcinomas (Fig 4). Thus, the diagnostic yield of the double-contrast barium enema examination for confirmed neoplastic lesions 1 cm or larger was 5.1% (14 of 276 patients). The 21 neoplastic lesions in these 14 patients had a mean diameter of 1.7 cm (range, 1–5 cm). Two of these 21 lesions were located in the rectum, seven in the sigmoid colon, one in the descending colon, two in the splenic flexure, four in the transverse colon, two in the ascending colon, and three in the cecum. Twelve (57%) of the 21 neoplastic lesions 1 cm or larger were located proximal to the rectosigmoid colon, and nine (43%) were located proximal to the splenic flexure.

Our retrospective review of the radiographs from these double-contrast barium enema examinations corroborated the original size measurements for all 23 confirmed lesions that measured 1 cm or larger at double-contrast barium enema examination, not accounting for magnification.

Polyps Smaller than 1 cm

Twenty-one (50%) of the 42 patients who had polyps smaller than 1 cm at double-contrast barium enema examination underwent follow-up sigmoidoscopy (n = 9) or colonoscopy (n = 12) (Table 3). These 21 patients had a total of 33 polyps smaller than 1 cm. Endoscopic results confirmed the presence of 19 (58%) of the 33 radiographically diagnosed polyps in 12 (57%) of these 21 patients (eight had one polyp, three had two polyps, and one had five polyps). The mean diameter of the 19 confirmed polyps that were smaller than 1 cm was 0.5 cm (range, 0.2–0.9 cm). Five of these 19 polyps were located in the rectum, five in the sigmoid colon, one in the descending colon, three in the transverse colon, three in the hepatic flexure, one in the ascending colon, and one in the cecum. The histologic findings are summarized in Table 3.

Twelve (57%) of 21 patients (including three who had other true-positive polyps smaller than 1 cm) had a total of 14 polyps smaller than 1 cm at double-contrast barium enema examination (10 patients had one lesion and two had two lesions) that were not visualized at endoscopy, so these 14 polyps were con-

Figure 4

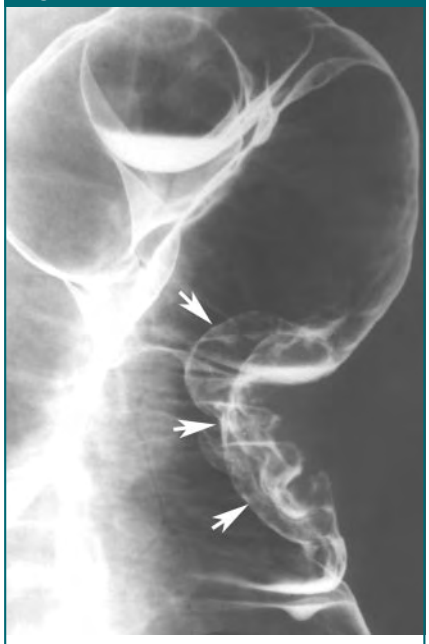

Figure 4: Polypoid mass in descending colon of 75-year-old man. Upright right posterior oblique spot radiograph of splenic flexure from screening double-contrast barium enema examination shows 5-cm polypoid lesion (arrows) on lateral wall of proximal descending colon. Resected lesion was an adenocarcinoma invading the serosa, with one of 11 positive lymph nodes.

Table 2

Summary of Findings for Double-Contrast Barium Enema Examination and Paired Colonoscopy ($n = 20$) or Sigmoidoscopy ($n = 4$) in 24 Patients with 32 Radiographically Diagnosed Polypoid Lesions 1 cm or Larger

Patient No.	Polyp Size (cm)	Confidence Level	Location	Endoscopic Findings	Histologic Findings
1	2.0	Low	Transverse colon	Negative	· · ·
2*	1.0	Moderate	Sigmoid colon	Positive	Hyperplastic polyp
3*	1.0	Low	Sigmoid colon	Negative	· · ·
4	1.5	High	Rectum	Positive	Tubulovillous adenoma
5*	1.2	Moderate	Sigmoid colon	Negative	· · ·
6	1.0	Moderate	Transverse colon	Positive	Tubular adenoma
7	1.0	High	Cecum	Positive	Tubulovillous adenoma
8†					
Polyp 1	1.7	High	Rectum	Positive	Tubular adenoma with moderate dysplasia
Polyp 2	1.1	High	Sigmoid colon	Positive	Tubular adenoma
9	4.5	High	Sigmoid colon	Positive	Adenocarcinoma
10	1.3	High	Splenic flexure	Positive	Villous adenoma with marked dysplasia
11*	1.0	Low	Sigmoid colon	Negative	· · ·
12	1.3	High	Cecum	Positive	Tubular adenoma with mild dysplasia
13					
Polyp 1	2.0	High	Transverse colon	Positive	Tubulovillous adenoma with mild dysplasia
Polyp 2	1.2	High	Splenic flexure	Positive	Tubular adenoma with mild dysplasia
Polyp 3	1.0	High	Transverse colon	Positive	Tubular adenoma with mild dysplasia
Polyp 4	1.0	Low	Ascending colon	Positive	Tubular adenoma with mild dysplasia
14	1.2	High	Cecum	Positive	Tubular adenoma
15	1.0	Moderate	Ascending colon	Positive	Tubular adenoma
16	1.0	Moderate	Rectum	Positive	Hyperplastic polyp
17					
Polyp 1	2.2	High	Sigmoid colon	Negative	· · ·
Polyp 2	1.1	High	Sigmoid colon	Negative	· · ·
18	1.8	Low	Ascending colon	Negative	· · ·
19					
Polyp 1	2.3	High	Sigmoid colon	Positive	Tubulovillous adenoma with mild dysplasia
Polyp 2	2.0	High	Sigmoid colon	Positive	Tubulovillous adenoma with mild dysplasia
20	1.1	Moderate	Transverse colon	Positive	Tubular adenoma with mild dysplasia
21	1.0	Moderate	Transverse colon	Negative	· · ·
22	1.0	High	Sigmoid colon	Positive	Tubular adenoma
23	1.1	High	Sigmoid colon	Negative‡	· · ·
24					
Polyp 1	5.0	High	Descending colon	Positive	Adenocarcinoma
Polyp 2	2.0	High	Sigmoid colon	Positive	Tubulovillous adenoma with moderate dysplasia
Polyp 3	1.4	High	Sigmoid colon	Positive	Tubulovillous adenoma

Note.—Unless otherwise indicated, patients underwent follow-up with colonoscopy.

* Patient underwent follow-up with sigmoidoscopy.

† Results of colonoscopy revealed an additional 1.5-cm polypoid lesion that was not seen at double-contrast barium enema examination.

‡ Endoscopy report indicated poor preparation.

sidered to be false-positive radiographic findings (Table 3). The mean diameter of the 14 false-positive polyps was 0.5 cm (range, 0.2–0.9 cm). The higher percentage of false-positive results in this group than in the group with polyps 1 cm or larger presumably reflects the greater degree of difficulty in differentiating smaller polyps from adherent stool or other artifacts at double-contrast barium enema examination.

Three (14%) of the 21 patients with polyps smaller than 1 cm who underwent follow-up sigmoidoscopy ($n = 1$) or colonoscopy ($n = 2$) had an additional eight polyps (five hyperplastic polyps and three tubular adenomas) smaller than 1 cm that were not detected at double-contrast barium enema examination.

None of the 21 patients with polyps smaller than 1 cm at double-contrast barium enema examination and subsequent endoscopy had polypoid lesions 1 cm or larger at endoscopy.

No Polypoid Lesions

None of the 52 patients with negative results at screening double-contrast barium enema examination who underwent follow-up sigmoidoscopy (n = 51) or colonoscopy (n = 1) were found to have polypoid lesions 1 cm or larger at endoscopy.

Advanced Neoplastic Lesions

In addition to the 14 patients with 21 neoplastic lesions 1 cm or larger at double-contrast barium enema examination, three (25%) of the 12 patients with endoscopically proved polyps smaller than 1 cm at double-contrast barium enema examination had a total of three advanced neoplastic lesions; all three patients had tubulovillous adenomas, with mild dysplasia in one lesion and marked dysplasia in one lesion. The mean diameter of these lesions was 0.7 cm (range, 0.6–0.9 cm). The three advanced neoplastic lesions that were smaller than 1 cm in diameter were located in the sigmoid colon in two patients and in the ascending colon in one patient.

When the three patients who had advanced neoplastic lesions that were smaller than 1 cm were combined with the 14 patients who had neoplastic lesions that were 1 cm or larger, 17 had a total of 24 advanced neoplastic lesions, including 11 tubular adenomas (with mild dysplasia in five lesions and moderate dysplasia in one lesion), 10 tubulovillous adenomas (with mild dysplasia in four lesions, moderate dysplasia in one lesion, and marked dysplasia in one lesion), one villous adenoma with marked dysplasia, and two adenocarcinomas. Thus, the diagnostic yield of the double-contrast barium enema examination for advanced neoplastic lesions, regardless of size, was 6.2% (17 of 276 patients). Thirteen (54%) of the 24 advanced neoplastic lesions were located proximal to the rectosigmoid colon, and 10 (42%) were located proximal to the splenic flexure.

When the 17 patients with advanced neoplastic lesions at double-contrast barium enema examination were stratified according to age, the diagnostic yield of this procedure was 5.1%

Table 3

Summary of Findings for Double-Contrast Barium Enema Examination and Paired Colonoscopy (n = 12) or Sigmoidoscopy (n = 9) in 21 Patients with 33 Radiographically Diagnosed Polypoid Lesions Smaller than 1 cm

Patient No.*	Polyp Size (cm)	Location	Endoscopic Findings	Histologic Findings
1	0.8	Rectum	Negative	· · ·
2	0.2	Rectum	Negative	· · ·
3				
Polyp 1	0.2	Transverse colon	Positive	Tubular adenoma
Polyp 2	0.2	Transverse colon	Positive	Hyperplastic polyp
4	0.3	Rectum	Negative	· · ·
5				
Polyp 1	0.6	Hepatic flexure	Positive	Tubular adenoma
Polyp 2	0.6	Cecum	Positive	Tubular adenoma
6	0.8	Rectum	Negative	· · ·
7				
Polyp 1	0.9	Hepatic flexure	Positive	Tubular adenoma
Polyp 2	0.9	Rectum	Negative	· · ·
Polyp 3	0.2	Sigmoid colon	Positive	Hyperplastic polyp
Polyp 4	0.2	Hepatic flexure	Negative	· · ·
8	0.9	Descending colon	Negative	· · ·
9	0.2	Rectum	Positive	Hyperplastic polyp
10	0.2	Rectum	Positive	Tubular adenoma with mild dysplasia
11				
Polyp 1	0.9	Ascending colon	Positive	Tubulovillous adenoma
Polyp 2	0.7	Ascending colon	Negative	· · ·
12				
Polyp 1	0.4	Rectum	Positive	Hyperplastic polyp
Polyp 2	0.3	Rectum	Positive	Hyperplastic polyp
Polyp 3	0.5	Sigmoid colon	Positive	Hyperplastic polyp
Polyp 4	0.8	Sigmoid colon	Positive	Tubular adenoma with mild dysplasia
Polyp 5	0.6	Sigmoid colon	Positive	Tubulovillous adenoma with marked dysplasia
13	0.6	Descending colon	Negative	· · ·
14	0.4	Transverse colon	Positive	Hyperplastic polyp
15	0.3	Rectum	Positive	Hyperplastic polyp
16				
Polyp 1	0.3	Sigmoid colon	Negative	· · ·
Polyp 2	0.4	Descending colon	Negative	· · ·
17	0.5	Hepatic flexure	Negative	· · ·
18	0.4	Hepatic flexure	Positive	Tubular adenoma
19				
Polyp 1	0.3	Descending colon	Positive	Tubular adenoma
Polyp 2	0.3	Descending colon	Negative	· · ·
20	0.5	Ascending colon	Negative	· · ·
21	0.7	Sigmoid colon	Positive	Tubulovillous adenoma with mild dysplasia

* Three of 21 patients who underwent follow-up with sigmoidoscopy (n = 1) or colonoscopy (n = 2) had an additional eight polyps smaller than 1 cm (five hyperplastic polyps and three tubular carcinomas) that were not detected at double-contrast barium enema examination.

(eight of 157 patients) for patients 50–59 years old, 6% (five of 85 patients) for patients 60–69 years old, and 12% (four of 34 patients) for patients older than 70 years.

Complications

Three (1.1%) of the 276 people who underwent screening double-contrast barium enema examination experienced minor complications during or immediately after the procedures, including a syncopal episode in two patients and a transient episode of wheezing in one patient. The syncopal episodes presumably represented vasovagal reactions to the intravenous injections, and the wheezing may have been caused by an allergic reaction to the barium or glucagon or to anxiety and stress associated with the procedure. There were, however, no serious complications during these examinations, and no deaths were reported within 1 month of the time of the examination.

Discussion

The infrequent use of double-contrast barium enema examinations as a screening tool for colorectal cancer may be related to one or more factors, including the common perception that this procedure fails to demonstrate a substantial number of clinically important neoplastic lesions (24,25). To our knowledge, however, no previously published studies to date have evaluated the diagnostic yield of double-contrast barium enema examinations for colorectal cancer screening in average-risk adults older than 50 years.

In our retrospective study, double-contrast barium enema examinations had a diagnostic yield of 5.1% (14 of 276 patients) for neoplastic lesions (benign or malignant) 1 cm or larger and 6.2% (17 of 276 patients) for advanced neoplastic lesions, regardless of size. Advanced lesions were previously defined as adenomas 1 cm or larger or as any neoplastic lesions containing villous features, high-grade dysplasia, or invasive carcinoma (20–22).

Because follow-up endoscopy was not performed in eight (25%) of 32 patients with polypoid lesions 1 cm or larger or in 21 (50%) of 42 patients with polyps smaller than 1 cm at screening double-contrast barium enema examination and because we only included proved cases, the previous values represent conservative estimates of our actual diagnostic yields for this examination. Furthermore, none of the 51 patients with negative results at screening double-contrast barium enema examination who underwent follow-up sigmoidoscopy were found to have polypoid lesions 1 cm or larger in the rectosigmoid colon.

In other studies, researchers have shown that screening colonoscopy in asymptomatic adults has a yield of 5.0%–9.5% for colonic neoplasms 1 cm or larger (20,22,26) and a yield of 4.6%–11.7% for advanced colonic neoplasms, regardless of size (20–22) (Table 4). Thus, the diagnostic yield of the screening double-contrast barium enema examination appears to be within the lower range of that reported for screening colonoscopy. At the same time, double-contrast barium enema examinations cost less than half as much as colonoscopy (27) and are associated with fewer complications and a much lower perforation and mortality rate (10). Our experience suggests that the frequent reluctance to use double-contrast barium enema examinations for colorectal screening is not warranted and that this technique can have a substantially greater role in these individuals.

Endoscopic results confirmed the presence of 23 (72%) of 32 polypoid lesions 1 cm or larger that were detected at screening double-contrast barium enema examination in 16 patients, with nine false-positive lesions in eight patients. In our retrospective review of false-positive lesions, however, our confidence level was high for three (33%) of those nine false-positive lesions. It is therefore possible that the latter three patients had false-negative endoscopic results, because colonoscopy can miss a small percentage of lesions larger than 1 cm (28). More importantly, of the 24 patients with polypoid lesions 1 cm or larger at double-contrast barium enema examination who underwent endoscopic follow-up (colonoscopy, 20 patients; sigmoidoscopy, four patients), we were aware of only one patient in whom colonoscopy revealed an additional polypoid lesion larger than 1 cm that was not detected at double-contrast barium enema examination. This individual, however, had two other radiographically diagnosed lesions 1 cm or larger, so colonoscopy had been recommended despite our inability to demonstrate the third lesion.

As expected, our diagnostic yield for advanced colonic neoplasms increased with advancing age, from 5.1% (eight of 157 patients) for patients 50–59 years old to 12% (four of 34 patients) for patients over 70 years old. We detected more advanced colonic neoplasms in older individuals, despite the fact that technically adequate double-contrast barium enema examinations are more difficult to obtain in the elderly because of generalized debility that affects our ability to perform the maneuvers required for this examination. On

Table 4

Prevalence of Large Colonic Neoplasms or Advanced Colonic Neoplasms at Colonoscopy in Previously Published Studies

Study	Prevalence of Large Colonic Lesions (%)*	Prevalence of Advanced Neoplasms (%)†
Lieberman et al (20)	9.5	10.5
Betes et al (22)	5.0	11.7
Imperiale et al (21)	· · ·	4.6
Harewood and Lieberman (26)	5.1	· · ·

* Large colonic lesions were defined as neoplasms that measured 1 cm or larger.

† Advanced neoplasms were defined as any advanced colonic neoplasm, regardless of size.

the other hand, detection of adenomas, even of those that are advanced, becomes less important in the elderly because of the long interval (10–15 years) required for the transformation of adenomas (even those that are larger than 1 cm) to cancers (29) and because of the shorter life expectancy of these individuals.

It is important to emphasize that screening double-contrast barium enema examinations should be performed primarily for asymptomatic average-risk adults older that 50 years. The overall prevalence of colonic polyps 1 cm or larger in such screening subjects ranges from 5%–15%, depending on the age of these individuals (11). In our study, the overall positivity rate for double-contrast barium enema examinations was 11.6% (32 of 276 patients) for polypoid lesions 1 cm or larger and 17% (47 of 276 patients) for polyps 6 mm or larger. Even if a lower size threshold is used, our experience suggests that only a small percentage of patients who undergo double-contrast barium enema examinations for colorectal cancer screening will require follow-up colonoscopy for the potential removal of these lesions, thereby decreasing the costs and complications of colonoscopy and enabling more efficient use of limited endoscopic resources.

The availability of the double-contrast barium enema examination as a reimbursable alternative to colonoscopy for colon cancer screening has added importance because of the underuse of screening colonoscopy in the eligible population. Many patients older than 50 years are uninsured, and even those with insurance often experience long waiting times for colonoscopy because of limited resources for this procedure (30). The lower cost of the double-contrast barium enema procedure could also allow for more efficient allocation of financial resources for publicly funded screening programs.

The results of previous studies have shown that there has been a proximal shift in the distribution of colorectal polyps and cancer so that about 50% are located proximal to the rectosigmoid colon and 30% are located proximal to the splenic flexure (8,9). In our study, 13 (54%) of 24 advanced neoplastic lesions were located proximal to the rectosigmoid colon and 10 (42%) were located proximal to the splenic flexure. Our findings underscore the benefit of performing a total colon examination for colorectal cancer screening in order to avoid missing potentially important neoplastic lesions. As has been noted by others, the use of sigmoidoscopy as the sole screening tool for colorectal cancer is no more logical than performing mammography on one breast to screen women for breast cancer (31).

Our retrospective study has a number of substantial limitations, including the lack of endoscopic follow-up in patients with negative screening barium enema results. Because the double-contrast barium enema examination was performed as the primary screening procedure for colorectal cancer in our study population, colonoscopy was reserved mainly for patients with neoplastic lesions that were reported during barium enema examination. As a result, colonoscopy was rarely performed on patients who had negative results at barium enema examination, and we were unable to determine the sensitivity of the double-contrast barium enema examination in demonstrating colorectal neoplasms. Nevertheless, 51 (25.2%) of the 202 patients with negative screening barium enema results underwent follow-up sigmoidoscopy as a complementary examination for demonstrating neoplastic lesions in the sigmoid colon (23); none of these patients were found to have lesions in the rectosigmoid colon that had been missed at double-contrast barium enema examination.

Our study is also limited by the lack of endoscopic follow-up data in a substantial number of patients who had positive screening barium enema results. Only 45 (61%) of the 74 patients with neoplastic lesions of any size at double-contrast barium enema examination underwent follow-up sigmoidoscopy or colonoscopy; 24 (75%) of 32 patients with polypoid lesions 1 cm or larger at barium enema examination underwent endoscopy compared with 21 (50%) of 42 with patients with polypoid lesions smaller than 1 cm. Thus, larger lesions were more likely to result in endoscopic follow-up, presumably because our referring clinicians recognized that polypoid lesions 1 cm or larger were more likely to harbor carcinoma (2,3). Also, four patients who had polypoid lesions 1 cm or larger at screening barium enema examination underwent sigmoidoscopy rather than colonoscopy, but these lesions were identified as being confined to the rectosigmoid colon during double-contrast barium enema examination and therefore were amenable to sigmoidoscopic evaluation and removal.

Our reliance on colonoscopy as the reference standard for the presence or absence of colonic neoplasms is also problematic because colonoscopy is not an infallible technique for the detection of colonic polyps or even large lesions (32). Despite these limitations, our study has the advantage of reflecting actual practice rather than being susceptible to the potential bias associated with the artificial environment of a prospective research protocol in which the examiners are cognizant of the study context.

It should also be recognized that our findings in a Veterans Affairs Medical Center population (virtually all elderly men with coexisting medical problems) cannot necessarily be generalized to a more diverse screening population that consists of men and women with varying health status. Because patients seen in the Veterans Affairs health system are primarily men and because male sex is associated with a higher prevalence of advanced colonic neoplasms, our screening population might also be expected to have a higher frequency of advanced lesions than a screening population consisting of both sexes. On the other hand, two of the colonoscopic screening studies with diagnostic yields in the range of ours for the detection of advanced lesions had comparable screening populations (20,26).

Our inability to obtain long-term follow-up also prevented us from being able to determine the eventual clinical benefit of screening and its effect on the mortality from colorectal cancer in our screening population. Previously cited

colonoscopic studies, however, also lacked similar data regarding clinical outcomes.

Another limitation is our use of the original radiographic measurements to determine polyp size because conventional radiographs are associated with a magnification factor of about 10%–20%. We preferred to use the original measurements because the decision for endoscopy was partly based on the reported polyp size. As a result, some of the neoplastic lesions that were at or just above the 1 cm threshold on double-contrast barium enema images could have been slightly smaller than 1 cm after correction for magnification. However, polyp size also tends to be overestimated at endoscopy (33), potentially inflating the prevalence of polyps larger than 1 cm in previous colonoscopic studies.

CT colonography (also known as virtual colonoscopy) has received widespread attention as a noninvasive alternative to conventional colonoscopy for colorectal cancer screening (12). Unlike the double-contrast barium enema examination, which requires rectal administration of barium and air into the colon, CT colonography requires instillation of only air, and less procedure time and patient maneuvering are needed for this procedure. Patient compliance may also be improved by the development and refinement of oral stool-labeling agents that eliminate the need for colonic preparation during CT colonography (12). Nevertheless, in recent studies that used colonoscopy as the reference standard, the sensitivity of CT colonography in screening populations has varied from 46%–94% for the detection of polyps 1 cm or larger (34–37).

In other investigations (including one multi-institutional study) in which double-contrast barium enema examinations and CT colonography were performed in the same patients, these examinations were found to have comparable sensitivities for the detection of polyps 1 cm or larger (38,39). On the other hand, CT colonography is more expensive than a double-contrast barium enema examination and is associated with a high false-positive rate for the detection of polyps 5–10 mm (40). Possible explanations for the variable performance of this new imaging technology include the differing capabilities of the computer software used to generate the images and the differing skills and experience levels of the radiologists who interpreted these images. Whatever the explanation, CT colonography is an evolving technology, and its ultimate value for colorectal cancer screening will become clearer as more studies are performed.

In conclusion, screening double-contrast barium enema examination in average-risk adults older than 50 years had a diagnostic yield of 5.1% for neoplastic lesions 1 cm or larger and 6.2% for advanced neoplastic lesions of any size. Our findings indicate that the diagnostic yield of the double-contrast barium enema examination for colorectal cancer screening is within the lower range of that reported for screening colonoscopy. We therefore believe that double-contrast barium enema examinations can have a greater role in colorectal cancer screening.

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