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## A COMPARISON OF COLONOSCOPY AND DOUBLE-CONTRAST BARIUM ENEMA FOR SURVEILLANCE AFTER POLYPECTOMY

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### ABSTRACT

**Background** After patients have undergone colonoscopic polypectomy, it is uncertain whether colonoscopic examination or a barium enema is the better method of surveillance.

**Methods** As part of the National Polyp Study, we offered colonoscopic examination and double-contrast barium enema for surveillance to patients with newly diagnosed adenomatous polyps. Although barium enema was performed first, the endoscopist did not know the results.

**Results** A total of 973 patients underwent one or more colonoscopic examinations for surveillance. In the case of 580 of these patients, we performed 862 paired colonoscopic examinations and barium-enema examinations that met the requirements of the protocol. The findings on barium enema were positive in 222 (26 percent) of the paired examinations, including 94 of the 242 colonoscopic examinations in which one or more adenomas were detected (rate of detection of adenomas, 39 percent; 95 percent confidence interval, 33 to 45 percent). The proportion of examinations in which adenomatous polyps were detected by barium enema was significantly related to the size of the adenomas ( $P=0.009$ ); the rate was 32 percent for colonoscopic examinations in which the largest adenomas detected were 0.5 cm or less, 53 percent for those in which the largest adenomas detected were 0.6 to 1.0 cm, and 48 percent for those in which the largest adenomas detected exceeded 1.0 cm. Among the 139 paired examinations with positive results on barium enema and negative results on colonoscopic examination in the same location, 19 additional polyps, 12 of which were adenomas, were detected on colonoscopic reexamination.

**Conclusions** In patients who have undergone colonoscopic polypectomy, colonoscopic examination is a more effective method of surveillance than double-contrast barium enema. (N Engl J Med 2000;342:1766-72.)

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IT is accepted medical practice to remove adenomatous polyps when they are detected in the colon, to search for additional polyps, and to arrange for long-term follow-up of the patient. This approach is based on evidence that adenomatous polyps are precursors of colorectal cancer and that removing them will prevent colorectal cancer.<sup>1</sup> Periodic examinations have been recommended after polypectomy because of the high frequency of detection of adenomatous polyps at follow-up.<sup>2-4</sup> In previous analyses of data from the National Polyp Study, we assessed surveillance intervals after colonoscopic removal of adenomatous polyps.<sup>5,6</sup> In the current study, we compared colonoscopic examination and double-contrast barium enema to determine whether both methods are needed for surveillance or whether barium enema could replace colonoscop-

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ic examination.<sup>7</sup> Our study differs from prior assessments of surveillance after polypectomy because it was blinded and prospective.<sup>8-12</sup>

## METHODS

### Patients

The National Polyp Study was a randomized, controlled trial designed to assess surveillance strategies in patients after colonoscopic removal of newly diagnosed adenomas. All patients referred for initial colonoscopy or polypectomy from November 1980 to February 1990 at one of seven participating clinical centers were identified. Those with newly diagnosed adenomas who met the eligibility criteria and consented to participate were randomly assigned to undergo a colonoscopic examination three years after the initial colonoscopic examination or at both one and three years. Patients in both groups were offered a surveillance examination at six years. At each follow-up examination, the patients were offered both double-contrast barium enema and colonoscopic examination. The design of the study and follow-up results based on colonoscopic findings have been described previously.<sup>5,6</sup> All patients provided written informed consent for their participation in the study, and the study design was approved by the institutional review board at each participating center.

### Design of the Study

The study design included a prospective, blinded comparison of colonoscopy and double-contrast barium enema in detecting polyps at follow-up.<sup>5,7</sup> Only study endoscopists and radiologists performed the examinations and interpreted the results. Each center designated colon-cleansing regimens that were acceptable to the endoscopic and radiologic investigators. The regimens consisted of cathartic agents and hydration and, beginning in 1985, polyethylene glycol for colonoscopy. The use of enemas as part of the cleansing regimen was avoided before the barium enema because the products used interfered with the mucosal coating. Barium preparations were either HD-85 (Lafayette, Lafayette, Ind.) or Liquid Polibar (EZ-EM, Westbury, N.Y.). The standard barium-enema technique involved the acquisition of multiple (120 kVp) films, including horizontal-beam films. Radiologists had access to all prior films. The colonoscopic examination was performed approximately two weeks after the barium enema.

Findings on barium enema and colonoscopic examination were reported according to the location: rectum, sigmoid colon, descending colon, splenic flexure, transverse colon, hepatic flexure, ascending colon, or cecum. The size, location, and shape of each polyp were recorded. For each anatomical segment, findings of spasm, redundancy, stool, poor mucosal coating, or diverticulosis, and the level of confidence in each such finding, were reported. For barium enema, a high level of confidence indicated that the radiologist was unlikely to miss lesions that were larger than 1.0 cm, and a low level indicated that the radiologist could easily overlook a lesion that was larger than 1.0 cm. For colonoscopic examination, a high level of confidence indicated that the endoscopist had reached the cecum and could visualize the entire colon. The adequacy of the colonoscopic preparation and the completeness of the colonoscopic examination were also recorded.

The endoscopist inserted the colonoscope to the cecum and then withdrew the colonoscope to the next most distal segment of the colon. Polyps detected by colonoscopic examination were recorded for each anatomical segment by endoscopists who had no knowledge of the findings on barium enema (blinded colonoscopic examination). After the endoscopist reported observations for a given segment, the study coordinator informed the endoscopist of the results of barium enema for that segment. If there was a finding on barium enema that was not seen on colonoscopic examination, the endoscopist reexamined the segment several times with the patient in different positions until satisfied that the area was clear or a lesion had been found (unblinded colonoscopic examination). With the use of this approach, the co-

lonoscope did not need to be reinserted after the completion of the examination and the rate of polyps missed by colonoscopic examination could be determined.

All polyps detected by colonoscopic examination were removed, measured, and then classified histologically by the pathology review team according to National Polyp Study criteria as tubular adenomas or villous adenomas class A (proportion of villous component, 1 to 25 percent), B (26 to 75 percent), C (76 to 99 percent), or D (100 percent) or as nonadenomas (hyperplastic or other types, mainly normal mucosal tags).<sup>13</sup> After the histologic evaluation, the findings of the colonoscopic examination were classified on the basis of the presence or absence of adenomas and the size of the largest adenoma as showing no polyps, nonadenomatous polyps alone, adenomas that were no larger than 0.5 cm, adenomas that were 0.6 to 1.0 cm, or adenomas that were larger than 1.0 cm. The size of an adenoma was estimated by the endoscopist with use of open forceps during colonoscopic examination.

### Statistical Analysis

The primary comparison of colonoscopic examination and double-contrast barium enema was based on the classification of the findings on barium enema as positive (any polyps) or negative (no polyps) and the classification of the colonoscopic findings according to the presence and type (size and histologic characteristics) of polyps. The colonoscopic findings reported by endoscopists before the barium-enema findings were revealed were used as the reference measure for the barium-enema findings.

A secondary analysis assessed whether the same polyps detected by colonoscopic examination were also detected by barium enema. Polyps detected by both techniques within the same or an adjoining segment and whose sizes matched within 5 mm were considered a match. The matched polyps were true positives for barium enema relative to colonoscopic examination; polyps detected by colonoscopic examination but not by barium enema were considered to have been missed by barium enema or to represent a false negative result.

SAS statistical software (version 6.12, SAS Institute, Cary, N.C.) was used for all calculations. The chi-square statistic was used to compare differences in percentages; the Mantel-Haenszel chi-square test was used to compare differences in percentages with adjustment for covariates. The regression coefficient in a logistic model was used to assess whether there was a linear trend in the rate of detection with barium enema according to the size of the adenoma. All tests were two-sided, and a P value of 0.05 or less was considered to indicate statistical significance.<sup>14</sup>

## RESULTS

### Patients

Among the 1418 patients who underwent randomization,<sup>6</sup> 973 underwent one or more surveillance colonoscopic examinations, representing 80 percent of those alive and eligible for surveillance colonoscopic examination. These patients underwent 1762 surveillance colonoscopic examinations and 949 barium-enema examinations, of which 881 were paired with colonoscopic examinations. Nineteen paired examinations were excluded: the cecum was not reached in 12, the time between examinations exceeded six months in 6, and both were true in 1 case. The remaining 862 paired examinations meeting the protocol requirements were performed in 580 patients. The characteristics of these 580 patients at enrollment were similar to those of the 393 patients who did not have paired examinations (Table 1).

**TABLE 1. CHARACTERISTICS OF THE PATIENTS AT ENROLLMENT ACCORDING TO WHETHER THEY HAD PAIRED COLONOSCOPIC EXAMINATIONS AND BARIUM-ENEMA EXAMINATIONS.\***

CHARACTERISTIC	PATIENTS WITH PAIRED COLONOSCOPIC AND BARIUM-ENEMA EXAMINATIONS (N=580)	PATIENTS WITH COLONOSCOPIC EXAMINATION BUT NOT BARIUM-ENEMA EXAMINATION (N=393)
	number (percent)	
Sex		
Male	431 (74)	264 (67)
Female	149 (26)	129 (33)
Age		
<60 yr	227 (39)	170 (43)
≥60 yr	353 (61)	223 (57)
No. of adenomas†		
1	311 (56)	230 (60)
2	137 (25)	64 (17)
≥3	111 (20)	87 (23)
Size of largest adenoma‡		
≤0.5 cm	129 (23)	99 (26)
0.6–1.0 cm	211 (38)	143 (38)
>1.0 cm	218 (39)	138 (36)
Histologic type of worst adenoma‡		
Tubular	298 (53)	239 (63)
Villous class A	134 (24)	85 (22)
Villous class B	89 (16)	35 (9)
Villous class C or D	38 (7)	22 (6)
Most advanced type of dysplasia‡		
Low grade	506 (91)	342 (90)
High grade	53 (9)	39 (10)

\*Because of rounding, percentages may not total 100.

†Data on 33 patients were excluded because polyps were classified as adenomas by the local pathologists but as nonadenomas by the pathology review team (21 in the paired-examination group and 12 in the other group). In addition, data on the size of the adenoma at base line were missing for one patient in each group.

**Characteristics of the Paired Colonoscopic and Barium-Enema Examinations**

The average interval between the paired examinations was 16 days (median, 10; range, 2 to 164; interquartile range, 2 to 20). There were 125 pairs (15 percent) in which the interval between examinations exceeded 30 days. Among the 862 paired examinations, 337 were performed as part of the one-year surveillance (39 percent), 361 as part of the three-year surveillance (42 percent), and 119 as part of the six-year surveillance (14 percent); 45 were performed at other times (5 percent). All were performed between November 1981 and November 1990. There were no major complications after any of the paired examinations. Findings that were reported with a high level of confidence were more frequent for colonoscopic examination than for barium enema. The confidence level for barium enema was lowest with respect to findings in the sigmoid colon because of the presence of redundancy and diverticulosis and in the ascending colon and cecum because of the presence of fecal residue and poor mucosal coating (Table 2).

**Findings on Examination**

Polyps were detected in 392 of the 862 colonoscopic examinations (45 percent); adenomas were detected in 242 colonoscopic examinations (28 percent), and adenomas that were more than 1.0 cm were identified in 23 colonoscopic examinations (3 percent) (Table 3). Findings on barium enema were positive in 222 of the 862 paired examinations (26 percent) and in 139 of the 392 colonoscopic examinations in

**TABLE 2. CHARACTERISTICS OF 862 PAIRED COLONOSCOPIC EXAMINATIONS AND DOUBLE-CONTRAST BARIUM-ENEMA EXAMINATIONS.**

SEGMENT	HIGH LEVEL OF CONFIDENCE IN OVERALL FINDINGS		FECAL RESIDUE		REDUNDANCY		SPASM		DIVERTICULOSIS ON BARIUM ENEMA	POOR MUCOSAL COATING ON BARIUM ENEMA
	COLONOSCOPIC EXAMINATION	BARIUM ENEMA	COLONOSCOPIC EXAMINATION	BARIUM ENEMA	COLONOSCOPIC EXAMINATION	BARIUM ENEMA	COLONOSCOPIC EXAMINATION	BARIUM ENEMA		
	number of examinations (percent)									
Rectum	821 (95)	599 (69)	26 (3)	99 (11)	7 (1)	19 (2)	8 (1)	9 (1)	8 (1)	47 (5)
Sigmoid colon	804 (93)	300 (35)	38 (4)	147 (17)	57 (7)	440 (51)	34 (4)	135 (16)	258 (30)	41 (5)
Descending colon	800 (93)	510 (59)	52 (6)	107 (12)	37 (4)	76 (9)	26 (3)	91 (11)	179 (21)	43 (5)
Splenic flexure	809 (94)	564 (65)	44 (5)	110 (13)	36 (4)	121 (14)	20 (2)	0	74 (9)	40 (5)
Transverse colon	811 (94)	555 (64)	44 (5)	159 (18)	46 (5)	36 (4)	13 (2)	41 (5)	61 (7)	56 (6)
Hepatic flexure	802 (93)	457 (53)	57 (7)	182 (21)	31 (4)	163 (19)	11 (1)	30 (3)	60 (7)	93 (11)
Ascending colon	805 (93)	395 (46)	59 (7)	264 (31)	19 (2)	67 (8)	10 (1)	38 (4)	66 (8)	133 (15)
Cecum	787 (91)	399 (46)	91 (11)	235 (27)	14 (2)	32 (4)	7 (1)	22 (3)	24 (3)	123 (14)

**TABLE 3.** FINDINGS OF 862 PAIRED COLONOSCOPIC EXAMINATIONS AND DOUBLE-CONTRAST BARIUM-ENEMA EXAMINATIONS.

COLONOSCOPIC FINDINGS*	NO. OF PAIRED EXAMINATIONS	POSITIVE FINDINGS ON BARIUM ENEMA (≥1 POLYP DETECTED)	NEGATIVE FINDINGS ON BARIUM ENEMA
		no. of examinations (%)	
Any polyp	392†	139 (35)	253 (65)
Any adenoma	242‡	94 (39)	148 (61)
Size of largest adenoma§			
≤0.5 cm	155	49 (32)	106 (68)
0.6–1.0 cm	64	34 (53)	30 (47)
>1.0 cm¶	23	11 (48)	12 (52)
Only nonadenomas	150	45 (30)	105 (70)
Hyperplastic	38	16 (42)	22 (58)
Other types	112	29 (26)	83 (74)
No polyps	470	83 (18)	387 (82)
Total	862	222	640

\*Examinations were classified according to the presence or absence of adenomas and the size of the largest adenoma, then according to the presence or absence of hyperplastic polyps.

†One polyp was detected in 213 of the 862 colonoscopic examinations (25 percent), two polyps in 98 examinations (11 percent), and three or more polyps in 81 examinations (9 percent).

‡One adenoma was detected in 164 of the 862 colonoscopic examinations (19 percent), two adenomas in 50 examinations (6 percent), and three or more adenomas in 28 examinations (3 percent).

§The proportion of colonoscopic examinations that were confirmed by barium enema differed significantly according to the size of the largest adenoma (P=0.009).

¶This category includes two malignant polyps that were larger than 1.0 cm.

||One polyp was detected in 153 of the 862 barium-enema examinations (18 percent), two polyps in 41 examinations (5 percent), and three or more polyps in 28 examinations (3 percent).

which one or more polyps were detected (rate of detection of polyps, 35 percent; 95 percent confidence interval, 31 to 40 percent). In the 470 pairs of examinations in which colonoscopic examination did not detect polyps, the findings on barium enema were negative in 387 cases (rate of agreement for negative findings, 82 percent; 95 percent confidence interval, 79 to 86 percent). The results of barium enema and colonoscopic examination were concordant in 526 (61 percent) of the examinations: 139 were concordant for polyps, and 387 were concordant for the absence of polyps.

Overall, one or more adenomas were detected in 242 colonoscopic examinations (28 percent); of these 242, the corresponding findings on barium enema were positive in 94 examinations (rate of detection, 39 percent; 95 percent confidence interval, 33 to 45 percent) (Table 3). Of the 155 colonoscopic examinations in which only small adenomas (≤0.5 cm) were detected, the findings on paired barium enema were positive in 49 examinations (rate of detection, 32 percent; 95 percent confidence interval, 25 to 39

percent). Of the 64 colonoscopic examinations in which the largest adenoma was 0.6 to 1.0 cm, the findings on paired barium enema were positive in 34 examinations (rate of detection, 53 percent; 95 percent confidence interval, 40 to 66 percent). Adenomas that were greater than 1.0 cm were detected in 23 colonoscopic examinations (3 percent), and the results of the corresponding barium enema were positive in 11 examinations (rate of detection, 48 percent; 95 percent confidence interval, 24 to 67 percent). The rate of detection for barium enema was significantly related to the size of the largest adenoma detected by colonoscopic examination (P=0.009).

In the paired examinations, two malignant polyps were detected by surveillance colonoscopic examination and were included in the group of adenomas that were larger than 1.0 cm.<sup>1</sup> One of these cancers was detected by barium enema, and one was not. Both these cancers were 1.5-cm cecal cancers. Three additional malignant polyps were detected by surveillance colonoscopic examination, but in these cases paired examinations were not performed.<sup>1</sup>

**Characteristics of the Polyps Identified**

The polyps detected by colonoscopic examination were matched according to size and location with polyps detected by barium enema and were the basis for the secondary analysis of the rate of detection associated with barium enema (Table 4). The 862 blinded colonoscopic examinations that were matched with barium-enema examinations detected 791 polyps, of which 375 were adenomas (47 percent) and 416 were nonadenomas (53 percent). Barium enema detected 160 of the 791 polyps detected by colonoscopic examination (20 percent). The rate of detection of adenomas by barium enema was significantly related to the size of the adenomas (P<0.001) and was lower for the 270 adenomas that were 0.5 cm or less (21 percent; 95 percent confidence interval, 17 to 26 percent) than for those that were 0.6 to 1.0 cm (42 percent; 95 percent confidence interval, 31 to 54 percent) and those that were more than 1.0 cm (46 percent; 95 percent confidence interval, 26 to 67 percent). The location of the adenomas also significantly affected the rate of detection by barium enema: the rate was higher for polyps on the left side of the colon, even after adjustment for differences in the size of the adenomas between the right and left sides of the colon (P=0.01). The rate of detection of any hyperplastic polyps by barium enema was similar to the rate of detection of adenomas that were 0.5 cm or smaller (P=0.25).

**Results of Unblinded Colonoscopic Examination for Patients with Negative Colonoscopic Findings and Positive Barium-Enema Findings**

An unblinded colonoscopic examination was done during 139 examinations in which the results of blind-

**TABLE 4.** HISTOLOGIC CHARACTERISTICS, SIZES, AND LOCATIONS OF 791 POLYPS ACCORDING TO WHETHER THEY WERE DETECTED BY BARIUM ENEMA.

CHARACTERISTICS OF POLYPS	NO. DETECTED BY COLONOSCOPIC EXAMINATION	DETECTED BY COLONOSCOPIC EXAMINATION AND BARIUM ENEMA*	DETECTED BY COLONOSCOPIC EXAMINATION BUT NOT BY BARIUM ENEMA	no. of polyps (%)	
Adenomas	375	103 (27)	272 (73)		
Size of largest adenoma†					
≤0.5 cm	270	58 (21)	212 (79)		
0.6–1.0 cm	81	34 (42)	47 (58)		
>1.0 cm	24	11 (46)	13 (54)		
Location of adenomas‡					
Left side of colon	168	57 (34)	111 (66)		
Right side of colon	207	46 (22)	161 (78)		
Nonadenomas	416	57 (14)	359 (86)		
Hyperplastic	98	19 (19)	79 (81)		
Other types	318	38 (12)	280 (88)		
Total	791	160	631		

\*These polyps were matched by size and location.

†The rate of detection of adenomas by barium enema differed significantly ( $P < 0.001$ ) according to the size of the adenoma.

‡The left side of the colon includes the splenic flexure, descending colon, sigmoid colon, and rectum. The right side of the colon includes the cecum, ascending colon, hepatic flexure, and transverse colon.  $P = 0.014$  for the comparison with barium enema after adjustment for the size of the adenoma.

**TABLE 5.** CHARACTERISTICS OF 19 POLYPS IN 18 PATIENTS THAT WERE NOT DETECTED BY BLINDED COLONOSCOPIC EXAMINATION BUT THAT WERE DETECTED BY UNBLINDED COLONOSCOPIC EXAMINATION.

PATIENT No.	TYPE OF POLYP	LOCATION OF POLYP	SIZE ON COLONOSCOPIC EXAMINATION	SIZE ON BARIUM ENEMA
			centimeters	
<b>Adenoma</b>				
1	Tubular	Cecum	0.3*	1.0*
2	Tubular	Hepatic flexure	0.2	0.5
	Tubular	Hepatic flexure	0.2	0.4
3	Tubular	Transverse colon	0.4	0.4
4	Tubular	Splenic flexure	0.5	0.6
5	Tubular	Descending colon	0.4	0.5
6	Tubular	Sigmoid colon	0.3	0.5
7	Tubular	Sigmoid colon	0.3	0.3
8	Tubular	Rectum	0.4*	1.1*
9	Tubular	Rectum	0.2	0.6
10	Tubular	Rectum	0.3	0.4
11	Villous A	Rectum	0.7	1.0
<b>Nonadenoma</b>				
12	Other type	Ascending colon	0.4	0.4
13	Other type	Transverse colon	0.2	0.4
14	Other type	Transverse colon	0.3	0.5
15	Other type	Descending colon	0.6	0.6
16	Hyperplastic	Sigmoid colon	0.4	0.6
17	Other type	Sigmoid colon	0.5	0.5
18	Other type	Rectum	0.5	0.5

\*The endoscopist considered the polyps to be matched on colonoscopic examination and barium enema despite the difference in size.

ed colonoscopic examination of a specific location differed from those for barium enema. Nineteen additional polyps were detected by unblinded colonoscopic examination, of which 12 were adenomas (Table 5). Therefore, the rate of missed adenomas with blinded colonoscopic examination was 20 percent, since 12 were detected by unblinded colonoscopic examination in addition to the 47 adenomas already detected by blinded colonoscopic examination. The rate of missed small adenomas was 26 percent (11 of 43) and of adenomas of 0.6 to 1.0 cm, 6 percent (1 of 16). No adenomas that were greater than 1.0 cm were missed.

## DISCUSSION

Since its introduction in the early 1970s, colonoscopy has become an important diagnostic and therapeutic tool for the examination of the colon.<sup>15</sup> Before colonoscopy became available, barium enema was the primary means of detection of polyps, and their removal required surgical colotomy.<sup>15</sup> The results of studies have supported the transition from the use of barium enema to the use of colonoscopy, suggesting a greater rate of detection of colonic neoplasia with colonoscopic examination and highlighting its usefulness for biopsy and polypectomy.<sup>12,16</sup> Our study design permitted a direct blinded comparison of colonoscopic examination with barium enema without interfering with complete colonoscopy in each patient.<sup>7</sup> We assessed whether colonoscopic examination alone, barium enema alone, or both were needed for surveillance.

Most early studies comparing colonoscopic examination and barium enema were retrospective and did not adjust for important variables.<sup>8-12</sup> These studies usually did not provide descriptions of the way in which polyps identified by both barium enema and colonoscopic examination were matched, and they often did not report the histologic appearance or the size of the polyps. Areas of concern in many studies have included the unequal expertise of the examiners, the use of disparate cleansing regimens for colonoscopic examination and barium enema, and the lack of blinding during examinations. In some studies, single-contrast and double-contrast examinations of the colon were combined. We used only double-contrast examinations, the allowable cleansing regimens were agreed on at a consensus meeting before the initiation of the study, all examinations were performed by endoscopic and radiologic investigators at each center who had similar levels of experience, and the examinations were carried out in a blinded fashion. During the study, we held regular meetings to ensure continued uniformity of practice and adherence to the protocol.

The prospective nature of the study allowed uniform documentation of the size, location, and pathological characteristics of the polyps.<sup>5</sup> The process of matching polyps detected by both barium enema and colonoscopic examination required accurate mapping of polyps by radiologists and endoscopists at each examination. Several factors were considered in matching polyps. Endoscopic assessment of location may vary, especially in redundant portions of the colon. Telescoping of the bowel can increase the difficulty of pinpointing the tip of the endoscope. For this reason, determining whether a polyp seen on a barium enema is precisely the same as that seen on colonoscopic examination may not be possible. An inaccuracy could result in a false positive or a false negative result for barium enema or a false negative result for colonoscopic examination. Also, the results of direct measurement of a polyp on an x-ray film can be at variance with estimates of size seen endoscopically or direct measurements of a removed polyp. We used the size on endoscopy as the reference size, since more polyps were detected by endoscopy than by barium enema.

We found that colonoscopic examination detected many more polyps than barium enema; about half of these polyps were adenomas, and the remainder were primarily normal mucosal tags, with some hyperplastic polyps.<sup>13</sup> The rate of detection with barium enema was related to the size of the adenomas.

A major question is whether the polyps that were not detected by barium enema are important in the long-term outcome of the patients. On the basis of prior observations in the National Polyp Study, it is clear that few clinically significant abnormalities are found after the initial colonoscopic examination.<sup>6</sup> Only

3 percent of the surveillance colonoscopic examinations detected adenomas that were greater than 1.0 cm. This finding is understandable, given current knowledge of the slow rate of progression of adenomas to carcinomas. The best estimate of the average time that it takes for a new polyp to grow and transform into cancer is 10 to 20 years.<sup>17,18</sup>

Is combining the two procedures beneficial? Performing both would result in additional costs, inconvenience, and risk. With the use of both procedures we found only 19 additional polyps in 18 patients — 12 of which, in 11 patients, were adenomas. We did not, however, conduct a formal cost-effectiveness study.

Colonoscopy was used as the reference measure with the knowledge that it is not perfect and does miss polyps. In our study, the rate of missed adenomas was 20 percent for colonoscopic examination, and all missed polyps were 1.0 cm or smaller. This rate is similar to the rates reported in other studies. A study of back-to-back colonoscopic examinations by Hixson et al. found that 15 percent of adenomatous polyps were missed, and all were less than 1.0 cm.<sup>19</sup> Rex et al. reported that back-to-back colonoscopic examinations missed 25 percent of adenomas that were less than 1.0 cm in size, 6 percent of adenomas that were at least 1.0 cm, and 24 percent of adenomas overall.<sup>20</sup> In addition, the colonoscope may not reach the cecum in all cases; the rate of complete examination ranges from 80 to 95 percent.<sup>21-23</sup> The rate of complete colonoscopic examination in our study (in which patients had already undergone a complete colonoscopic examination one or more years earlier) was 99 percent (868 of 881 examinations). Using colonoscopic examination as the reference procedure produced an unavoidable bias in favor of this procedure. We minimized this bias by using equivalent cleansing regimens for each type of examination, having investigators perform all the examinations, and using a blinded comparison agreed on before the study was initiated.<sup>7</sup>

Colonoscopic examination has become the preferred way of examining the colon for both the detection and the removal of polyps, replacing diagnostic barium enema as a means of surveillance. Our study supports this evolving clinical practice. The low rate of detection of large adenomas with barium enema is a drawback to the use of this radiologic technique as the primary surveillance tool. A double-contrast barium enema can be performed in cases in which the colonoscope does not reach the cecum.

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## APPENDIX

In addition to the authors, the following persons were members of the National Polyp Study Work Group: *Memorial Sloan-Kettering Cancer Center and Mount Sinai Hospital, New York* — R. Kurtz, M. Shike, H. Gerdes,

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