ORIGINAL ARTICLE

Localizing Colorectal Cancer by Colonoscopy

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Hypothesis: Colonoscopic localization of colorectal carcinoma is frequently inaccurate and unreliable.

Design: Consecutive case series.

Setting: Tertiary care teaching hospital.

Patients: Three hundred fourteen consecutive patients undergoing surgical resection for colorectal cancer from January 1, 2000, to December 31, 2003.

Intervention: Surgical resection for colorectal cancer.

Main Outcome Measure: Incidence of erroneous site localization.

Results: Two hundred thirty-six patients had complete endoscopic, pathologic, and operative records. Colonoscopy was inaccurate for tumor localization in 49 cases (21%). In 27 (11%) of these cases, a different procedure was required than initially planned; in an additional 10 cases (4%), the surgical approach required modification. Inaccurate localization was associated with previous colorectal procedures on both univariate analysis (odds ratio, 3.94; 95% confidence interval, 1.50-10.32; $P<.005$) and multivariate analysis (odds ratio, 4.47; 95% confidence interval, 1.64-12.08; $P=.003$). Having the colonoscopy performed by a surgeon trended toward protection from error on multivariate analysis (odds ratio, 0.47; 95% confidence interval, 0.20-1.08; $P=.07$). Age, sex, diverticular disease, endoscopist volume and years of training, and bowel preparation had no significant effect.

Conclusions: Colonoscopy has a considerable error rate for localization of colorectal cancer, especially when previous colorectal procedures have been performed. Adjunctive localizing techniques, such as endoscopic tattooing, should be strongly considered.

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IT WAS ESTIMATED THAT THERE would be approximately 150 000 new cases of colorectal cancer in the United States in 2004.[1] The current gold standard for detection of colorectal cancer is colonoscopy, with an estimated sensitivity of at least 85% to 95%.[2,3] Although colonoscopy is clearly reliable in identifying the presence of colorectal cancer, its ability to provide precise tumor localization is less certain. Several parallel developments have heightened the importance of this issue.

First, with increasing proficiency and more aggressive techniques such as endoscopic mucosal resection,[4] larger lesions can be removed endoscopically. Since the probability of a polypoid lesion harboring colorectal cancer clearly increases with size,[5] some of these patients will ultimately require colon resection where there is no residual palpable lesion. Further, with recent evidence supporting the safety of laparoscopic resections[6] and emphasis on smaller incisions, precise localization is critical to preoperative planning.

The aim of this study was to define the accuracy of colonoscopy in identifying the location of colorectal cancer.

METHODS

All of the patients who had a colorectal cancer diagnosed by colonoscopy and subsequently received a surgical procedure at Fletcher Allen Health Care, the teaching hospital of the University of Vermont College of Medicine, between January 1, 2000, and December 31, 2003, were eligible for this study. Patients who had their surgical resections at another institution were excluded. A retrospective review of inpatient and outpatient medical records was then conducted to record demographic data, any history of prior abdominal or colorectal procedures, history of diverticular disease, previous colorectal cancer, and the initial indication for colonoscopy.

Endoscopic records were reviewed to identify the endoscopist, completeness of the examination, method of sedation, complications, adequacy of bowel preparation, biopsy method, and use of endoscopic tattooing. The large intestine was divided into 13 segments from the anus to the cecum, and lesion localization was ascribed to 1 of these locations (**Table 1**). For rectal cancers, distance in centimeters from the anal verge was noted. In situations where more than 1 carcinoma was identified, all of the locations were recorded.

Each endoscopist's specialty was recorded from departmental staff registries and cross-referenced with databases from the online pub-

Table 1. Demographics

Variable	No. (%)*
Age at colonoscopy, mean (range), y	67.2 (33-92)
Sex, female	101 (42.8)
Colonoscopist specialty	
Colorectal surgeon	38 (16.1)
General surgeon	24 (10.1)
Gastroenterologist	156 (66.1)
Family practitioner	4 (1.7)
Internist	14 (5.9)
Colonoscopy performed by housestaff	41 (17.7)
Colonoscopist's experience, mean (range), y	17.5 (2-36)
Previous colon procedure	19 (8.1)
Other abdominal procedure	97 (41.4)
Appendectomy	40
TAHBSO	29
Colorectal procedure	19
Cholecystectomy	19
Inguinal hernia	10
Ventral hernia	7
Umbilical hernia	3
Cesarean section	6
Tubal ligation	7
Previous abdominal radiation therapy	4
Vascular	2
Other	10
Known history of diverticulosis	31 (13.2)
First colorectal cancer diagnosis	224 (96.5)
Indication for colonoscopy	
Anemia	40 (16.9)
Hematochezia	72 (30.5)
Hemoccult-positive	27 (11.4)
Surveillance	30 (12.7)
Abnormal bowel function	13 (5.5)
Pain	17 (7.2)
Weight loss	3 (1.2)
Radiologic findings	6 (2.5)
Melena	5 (2.1)
Family history/genetic	6 (2.5)
Other	15 (6.3)
Unknown	2 (0.8)
No. of lesions seen, mean	1.07
Size of lesion, mean (range), cm	4.1 (0.5-14.0)
Sedation used	221 (96.9)
Bowel preparation achieved	216 (95.5)
Diverticulosis noted	105 (47.3)
Total colonoscopy achieved	168 (73.3)
Reason for non–total colonoscopy	
Poor bowel preparation	5 (8.2)
Obstruction	38 (62.3)
Flexible sigmoidoscopy used	8 (13.1)
Pain	1 (1.6)
Other	4 (6.5)
Unknown	5 (8.2)

(continued)

Table 1. Demographics (cont)

Variable	No. (%)*
Lesion location at colonoscopy	
Anus	1 (0.4)
Anorectum	2 (0.8)
Rectum	61 (24.6)
Rectosigmoid	19 (7.6)
Sigmoid	58 (23.3)
Descending colon	5 (2.0)
Splenic flexure	8 (3.2)
Transverse colon	17 (6.8)
Hepatic flexure	18 (7.2)
Ascending colon	24 (9.7)
Cecum	30 (12.0)
Ileocecal valve	4 (1.6)
Surgery category	
Local excision	26 (11.0)
Abdominoperineal resection	12 (5.0)
Coloanal anastomosis	9 (3.8)
Anterior resection	50 (21.1)
Sigmoid resection	35 (14.8)
Left hemicolectomy	16 (6.8)
Right hemicolectomy	73 (30.9)
Subtotal colectomy	13 (5.5)
Other	2 (0.8)

Abbreviation: TAHBSO, total abdominal hysterectomy with bilateral salpingo-oophorectomy.
*Unless otherwise indicated.

lic registry of the American Medical Association, Chicago, Ill. The number of years of training was extrapolated from the year of medical school graduation to the date of the endoscopic examination. Operative notes were carefully reviewed, and tumor localization was recorded. The pathologic report was reviewed to identify lesion size and to confirm the presence of a colorectal malignancy. All of the patient information was coded without identifying data in compliance with Health Insurance Portability and Accountability Act confidentiality requirements. The study was approved by the institutional review board of the University of Vermont College of Medicine.

All of the statistical analysis was performed using MiniTab software, version 14 (Minitab Inc, State College, Pa). The relationship between the specialty of the colonoscopist and lesion localization was examined using a χ^2 analysis. This analysis was also performed with recategorizing the endoscopist as a surgeon (general or colorectal surgeons) vs nonsurgeon (all other specialties).

To delineate which variables would best predict whether an error would be made in lesion localization, unadjusted logistic regression analyses were performed for each covariate of interest, yielding crude odds ratios (ORs) for lesion localization error. All of the covariates with unadjusted *P* values of .25 or less were then entered into a backward selection process. Covariates altering other parameter estimates by more than 10% and not judged to be collinear with those affected variables were considered to be confounders and were left in the model. Eliminated covariates were later reentered in the final model to assess confounding and collinearity by those factors. Hypothesis tests were 2-sided, and the adjusted effect estimates indicate the influence of demographic and risk-factor variables on lesion localization error for all of the patients collectively. Hosmer-Lemeshow goodness-of-fit statistics were calculated to assess the predictability of the final models.

RESULTS

There were 314 patients who underwent resection of a colorectal malignancy detected by colonoscopy during the study period. Of them, 236 patients had complete inpatient and outpatient medical records, had complete endoscopic, operative, and pathologic reports, and were included in the analysis. Patient demographics and characteristics are outlined in Table 1. Forty-nine patients (21%) had erroneous localization. Crude effect estimates and 95% confidence intervals (CIs) for lesion localization errors are shown in **Table 2** and **Table 3**.

General surgeons were 40% more likely to correctly localize a colonic lesion (OR=0.59; 95% CI, 0.19-1.85) as compared with gastroenterologists. Colorectal surgeons were 55% more likely (OR=0.45; 95% CI, 0.16-1.24) and family practitioners/internists were over 80% more likely (OR=0.17; 95% CI, 0.02-2.36) to correctly localize a colonic lesion at colonoscopy as compared with gastroenterologists. However, the numbers were small, and none of these comparisons achieved statistical significance. When colonoscopists were examined on the basis of surgical vs nonsurgical training, a trend toward a protective effect was observed (OR=0.47; 95% CI, 0.20-1.08; $P=.07$).

Using the volume of colonoscopies performed per physician within this patient set, this variable was compared with colonic lesion localization error to determine whether physicians who performed more colonoscopies were less likely to make an error. However, no association was observed (OR=1.00; 95% CI, 0.98-1.03). The number of years of experience by colonoscopists was marginally protective—each year of training afforded a 3% odds of not making an error in localization (OR=0.97; 95% CI, 0.94-1.01; $P=.14$).

Table 2. Univariate Analyses

Variable	Crude OR (95% CI)	*P* Value
Age, y*	1.02 (0.99-1.05)	.19
Sex		
Male	1.00	NA
Female	1.70 (0.91-3.22)	.10
Previous colorectal procedure	3.94 (1.50-10.32)	<.005
Previous abdominal procedure	1.35 (0.71-2.54)	.35
Known history of diverticulosis	1.37 (0.57-3.27)	.49
Colonoscopist's specialty		
Gastroenterologist	1.00	NA
Family practice/internist	0.17 (0.02-2.36)	.10
Colorectal surgeon	0.45 (0.16-1.24)	.12
General surgeon	0.59 (0.19-1.85)	.40
Colonoscopist		
Nonsurgeon	1.00	NA
Surgeon	0.56 (0.26-1.24)	.16
Colonoscopy performed by housestaff	1.71 (0.08-3.67)	.17
Colonoscopist volume	1.00 (0.98-1.03)	.73
Training of colonoscopist, y†	0.97 (0.94-1.01)	.14
Successful bowel preparation	0.46 (0.13-1.65)	.24
Total colonoscopy achieved	0.76 (0.38-1.53)	.44
Lesion tattooed at colonoscopy	1.14 (0.40-3.25)	.81

Abbreviations: CI, confidence interval; NA, not applicable; OR, odds ratio.
*The odds ratio for age is that associated with being 1 year older, assuming other demographic characteristics are the same.
†The odds ratio for years of training is that associated with each additional year of training.

Patients who reported having had a colorectal procedure were nearly 4 times as likely to have an error made in their lesion localization (OR=3.94; 95% CI, 1.50-10.32; $P<.005$). However, having had prior abdominal procedures of other types was not significantly associated with an error (OR=1.35; 95% CI, 0.71-2.54). No factor associated with the colonoscopy procedure itself (bowel preparation use of sedation, tattooing, etc) was found to be associated with whether a lesion's location was correctly identified.

Some errors in localization may not alter surgical management. For example, a lesion seen in the rectosigmoid junction would be treated in essentially the same manner as a lesion in the sigmoid. Therefore, an analysis was also performed to assess the clinical significance of the localization errors. In 27 of the 49 patients with a discrepancy, it was judged that a different procedure was required than the one originally planned (**Table 4** and **Table 5**). In an additional 9 cases (4%), some modification was required.

COMMENT

This study showed that colonoscopy was inaccurate for tumor localization in 21% of the cases. In 11% of the cases, a substantively different procedure was required than initially planned; in an additional 4% of cases, the surgical approach required modification. The only clear risk factor for inaccurate localization was previous colorectal resection, which was highly associated on both univariate ($P<.005$) and multivariate ($P=.003$) analyses. Having the colonoscopy performed by a surgeon trended toward protection from error on multivariate analysis, but this did not quite reach statistical significance ($P=.07$).

This is an issue of considerable relevance. With continuing advances in endoscopic technology, larger lesions can increasingly be resected. Since the risk of a polyp harboring invasive malignancy clearly increases with size,[7] many of these patients will ultimately meet criteria for colon resection. At surgery, these patients do not have a residual lesion to palpate, and an intraoperative identification can be challenging. Relying on the preoperative endoscopic localization is fraught with hazard. Localizing techniques such as endoscopic tattooing[8] or perhaps newer microchip technologies[9] should probably be routine in this scenario.

This issue is further magnified when laparoscopic resection is planned, even when the gross lesion has not been endoscopically resected. Since there is limited ability to palpate the colon, lesions in certain "sanctuary" sites (eg, splenic flexure) may be especially difficult to identify. Small tumors that do not involve all layers of the

Table 3. Errors for Multivariate Analyses

	All Errors		Clinically Relevant Errors	
Variable	Crude OR (95% CI)*	*P* Value	Crude OR (95% CI)*	*P* Value
Previous colorectal procedure	4.47 (1.64-12.08)	.003	4.47 (1.41-14.22)	.01
Training of colonoscopist, y	0.96 (0.93-1.00)	.05	1.00 (0.95-1.05)	.09
Colonoscopy performed by surgeon	0.47 (0.20-1.08)	.07	0.39 (0.11-1.41)	.15

Abbreviations: CI, confidence interval; OR, odds ratio.
*These odds ratios were not altered with controlling for patient age, sex, other abdominal procedure, adequacy of bowel preparation, and performance of colonoscopy by housestaff.

Table 4. Clinically Significant Localization Errors in the Colon of 15 Patients

Patient No.	Preoperative Localization	Postoperative Localization
1	Sigmoid	Transverse colon
2	Transverse colon	Sigmoid
3	Cecum	Left transverse colon
4	Cecum	Splenic flexure
5	Sigmoid	Descending colon
6	Transverse colon	Descending colon
7	Sigmoid	Splenic flexure
8	Descending colon	Transverse colon
9	Sigmoid	Splenic flexure
10	Transverse colon	Descending colon
11	Sigmoid	Splenic flexure
12	Sigmoid	Splenic flexure
13	Splenic flexure	Hepatic flexure
14	Splenic flexure	Right colon
15	Cecum	Left transverse colon

Table 5. Clinically Significant Localization Errors in the Rectum of 12 Patients*

Patient No.	Preoperative Localization	Postoperative Localization
1	Rectum (10 cm)	Rectum (5 cm)
2	Rectosigmoid	Rectum (8 cm)
3	Rectosigmoid	Rectum (8 cm)
4	Sigmoid	Rectum (9 cm)
5	Sigmoid	Rectum (7 cm)
6	Sigmoid	Rectum (10 cm)
7	Rectum (9 cm)	Rectum (5 cm)
8	Sigmoid	Rectum (10 cm)
9	Rectum (10 cm)	Rectum (5 cm)
10	Sigmoid	Rectum (9 cm)
11	Rectum (10 cm)	Rectum (4 cm)
12	Sigmoid	Rectum (9 cm)

*Values in parentheses are distances from the anal verge.

bowel wall can also be challenging. Inaccurate site localization puts the patient at risk for inappropriate trocar placement, prolonged surgery and anesthesia, or even completely missing the lesion altogether. It was truly remarkable how disparate endoscopic localization and the actual tumor site were in some cases. There were quite a few cases in which lesions thought to be in the right colon were actually left-sided lesions and vice versa.

Particular emphasis must be made of tumor localization for rectal carcinomas. In 12 cases, errors in localization of rectal carcinomas required a change in operative approach. Quite often, a lesion described as being in the rectosigmoid or sigmoid was actually in the rectum, sometimes rather close to the anal verge. This has substantial clinical importance. First, as opposed to more proximal lesions, patients with stage II or III rectal cancer are typically treated preoperatively with neoadjuvant chemoradiation.[10] Erroneous localization can easily lead to the inappropriate use of adjuvant therapy. Second, there is a substantial difference in the morbidity and functional outcomes of sigmoid resection as compared with low anterior resection.[11] Obviously, neither the surgeon nor the patient would like to find out intraoperatively that an abdominoperineal resection rather than a low anterior resection is required.

In this series, all of these localization errors in the rectum were "corrected" preoperatively, as we routinely perform rigid proctosigmoidoscopy on any patient with colonoscopic localization thought to be in the rectosigmoid or rectum, or for lesions less than 20 cm from the anal verge.

We expected that having a colonoscopy performed by a surgeon would protect against localization errors, since localization is far more important to the operating surgeon than to the endoscopist. Although having colonoscopy performed by a surgeon did trend toward protection from error on multivariate analysis, the trend did not reach statistical significance. We were surprised by the dramatic effect of previous colectomy on localization errors. On multivariate analysis, such patients had 4½ times the risk of erroneous localization as did patients who had not had previous colectomy. Particular caution appears to be warranted in this subgroup.

Colonoscopy is clearly very sensitive for detecting colorectal cancers. However, our data suggest that there is a considerable incidence of erroneous localization. As such, relying on preoperative lower endoscopy to identify the precise location of a colorectal cancer may have major adverse consequences. Surgery may be unnecessarily prolonged, excessive amounts of bowel may be resected, trocars may be inappropriately placed, and the lesion may be missed altogether. Adjunctive techniques such as endoscopic tattooing should be routinely performed, at least for smaller or endoscopically resected lesions.

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