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The Impact of Suboptimal Preparation on Adenoma Miss Rates and the Factors Associated with Early Repeat Colonoscopy

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Abstract

Background—There are no guidelines for the recommended interval to the next examination after colonoscopy with suboptimal bowel preparation.

Aims—To identify factors associated with early repeat colonoscopy after initial examinations with suboptimal preparations, and to measure adenoma miss rates in this context.

Methods—We analyzed all colonoscopies over 3 years at a single, hospital-based endoscopy unit. We defined early repeat colonoscopies after a suboptimal preparation as those occurring <3 years after the index examination. Adenoma miss rates were calculated by dividing the number of lesions found on the second colonoscopy by the total on both examinations.

Results—Of 12,787 colonoscopies, preparation quality was suboptimal (poor or fair) in 3,047 (24%) patients. Among these 3,047 patients, repeat examination was performed in <3 years in 505 (17%). Factors associated with early repeat included lack of cecal intubation (OR 3.62, 95%CI 2.50–5.24) and finding a polyp (OR 1.55, 95%CI 1.17–2.07). Among 216 repeat colonoscopies with an optimal preparation, 198 adenomas were identified, of which 83 were only seen on the second examination, an adenoma miss rate of 42% (95%CI 35–49). The advanced adenoma miss rate was 27% (95%CI 17–41). For colonoscopies repeated in <1 year, the adenoma and advanced adenoma miss rates were 35% and 36% respectively.

Limitations—Single-center, retrospective study.

Conclusions—While a minority of patients undergo early repeat examination after a suboptimally prepared colonoscopy, the miss rates for suboptimally prepared colonoscopies were high, suggesting that suboptimal bowel preparation substantially decreases colonoscopy effectiveness, and may mandate an early follow-up examination.

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Keywords

Colonoscopy; colonic polyps; colorectal neoplasms; total quality management

INTRODUCTION

Colonoscopy is considered by many the preferred mode of screening for colorectal cancer (CRC).^{1–3} The effectiveness of any CRC screening program is critically dependent on an adequate bowel preparation. Suboptimal bowel preparation is associated with decreased adenoma detection^{4–5} and increased cost of colonoscopy by virtue of the decreased interval to repeat examination.⁶

Suboptimal bowel preparation occurs in more than 20% of all colonoscopic examinations,^{5, 7–8} yet guidelines do not specify the appropriate time interval in which to repeat the study in this setting. Guidelines do specify recommended intervals between colonoscopies depending on colonoscopic and histologic findings² presuming an optimal bowel preparation. Otherwise, it is left to the individual colonoscopist to decide how to adapt the recommended guidelines to cases with suboptimal bowel preparation.

A recent survey of gastroenterologists illustrates the variability among endoscopists regarding appropriate follow-up after a suboptimal bowel preparation.⁹ When shown images from suboptimally prepared colonoscopies, 24% of survey respondents disqualified at least one colonoscopy which mandated a prompt repeat, while the remainder did not disqualify any colonoscopy. Most participants recommended that the interval be curtailed to 3–5 years, while a minority suggested that it be repeated at the standard guideline-mandated interval. This variability and uncertainty is likely due, in part, to the fact that the incremental yield of repeating a colonoscopy after suboptimal preparation is not known. While an extensive literature exists on adenoma miss rates among individuals undergoing tandem colonoscopy with optimal preparation, the adenoma miss rate for the patient with a suboptimal preparation has not been described.

We aimed to identify factors associated with the decision to repeat the examination early after a suboptimally prepared colonoscopy. We also aimed to quantify adenoma miss rates among those pairs of colonoscopies separated by an interval shorter than the time suggested by current guidelines which assume an optimal preparation.^{2–3}

METHODS

This retrospective analysis was conducted at Columbia University Medical Center, a tertiary care institution located in upper Manhattan, New York, which serves a racially and socioeconomically diverse patient population. All colonoscopy procedures performed since the implementation of an electronic database, March 21, 2006 until December 31, 2008 were reviewed. This end date allowed for a minimum follow-up observation period of one year to December 31, 2009. If a patient underwent more than one colonoscopy during the study period, we considered the first chronological colonoscopy as the index examination. Patients with inflammatory bowel disease or a hereditary colon cancer syndrome listed as the clinical indication on the colonoscopy report were excluded as they require more frequent surveillance examinations.²

Preparation quality was recorded by the gastroenterologist (n=33) or colorectal surgeon (n=4) at the end of the procedure. The default preparation rating scale in the electronic endoscopy writer utilizes a four-option scale corresponding to the Aronchick score.¹⁰

“excellent,” “good,” “fair,” or “poor.” The endoscopy reporting system also allows for characterizing preparation quality as “satisfactory,” “unsatisfactory,” “adequate” or “not adequate.” As previously reported, we dichotomized preparation quality into “optimal” (including “excellent,” “good,” “adequate,” and “satisfactory”) and “suboptimal” (including “fair,” “poor,” “inadequate,” and “unsatisfactory”).⁷

Early repeat colonoscopy was defined as any colonoscopy that was performed within three years of the index examination. Three years is the shortest interval recommended in the current guidelines for surveillance colonoscopy in patients with a completely excised advanced adenoma or multiple adenomas found on the index examination. In turn, any colonoscopy repeated before three years represents an examination repeated earlier than suggested by guidelines.² Sensitivity analyses were also performed using a more stringent definition of an early repeat examination which was one repeated within one year of the index examination.

Univariate and multivariate analysis were used to assess factors associated with an early repeat colonoscopy among patients with a suboptimal preparation on the index examination. It was determined *a priori* that the following variables would be included in these analyses: patient age and gender, indication for colonoscopy, patient admission status (inpatient vs. outpatient), depth of colonoscope insertion, the participation of a trainee, the individual endoscopist (limited to those providers who performed ≥ 20 index colonoscopies with suboptimal preparation), the degree of suboptimal preparation (fair vs. poor), and the neoplastic findings on the index examination.

Adenoma Miss Rates

To quantify the yield of repeating the colonoscopy early in terms of adenoma detection, we included all patients in whom the cecum was reached on both the index and repeat examination and in which the preparation quality was considered optimal on the repeat examination. Patients in whom polypoid tissue was identified on the index examination but was not completely removed, as well as adenomas that were removed in piecemeal fashion, were excluded. Standard definition colonoscopes were used for all examinations.

Adenoma miss rates for repeated colonoscopies were calculated by dividing the total number of adenomas found on the second colonoscopy by the total number of adenomas found on the index colonoscopy plus the second colonoscopy.^{11–13} Adenoma size was reported by the endoscopist or determined after removal based on histology report. Adenomas were categorized by size (≤ 5 mm, 6–9 mm and ≥ 10 mm) and the miss rate for each size stratum was calculated using the aforementioned formula. Advanced lesions were defined as those ≥ 10 mm in diameter, exhibiting villous histology, or high-grade dysplasia. Missed lesions were also calculated on a per-patient basis where any patient with ≥ 1 adenoma identified on the repeat examination was counted as a patient with a missed lesion.

SAS 9.1 (Cary, NC) was used for all statistical calculations. The Institutional Review Board of Columbia University Medical Center approved this study. The requirement for informed consent was waived by the Institutional Review Board due to the retrospective nature of this study.

RESULTS

During the study period, 14,649 patients underwent colonoscopy. Upon exclusion of patients with familial cancer syndromes ($n=29$) and inflammatory bowel disease ($n=467$), 14,153 patients remained. Preparation quality was recorded in 12,787 (90%) of these patients.

The indication for the examination was screening in 5,480 (34%), surveillance in 2,577 (20%), and diagnostic in 4,723 (37%) individuals. The mean (SD) age was 61 (13.0) years, and 57% of the patients were female. The preparation quality was suboptimal in 3,047/12,787 (24%) patients. Of the 3,047 suboptimally prepared examinations, 505 (17%) were repeated within 3 years. Of the 505 patients whose suboptimally prepared colonoscopies were repeated early, 80 (16%) patients repeated the colonoscopy between 2 and 3 years after the index colonoscopy, 156 (31%) patients underwent repeat colonoscopy between 1 and 2 years after the index colonoscopy, and 269 (53%) patients underwent repeat colonoscopy within 1 year of the index colonoscopy.

Characteristics of patients who underwent early repeat colonoscopy, and comparisons with those who did not have an early repeat colonoscopy, are listed in Table 1. The proportion of patients with a suboptimal preparation who underwent an early repeat colonoscopy (17%) was greater than those with an optimal preparation (8%, $p<0.0001$).

Table 2 reports the patient and examination-related variables associated with an early repeat examination for a suboptimally prepared index colonoscopy. The strongest predictor of an early repeat examination was the failure to intubate the cecum on the initial colonoscopy (OR 3.62 95%CI 2.50–5.24). The presence of any polyp, regardless of histology, was associated with an early repeat examination (OR 1.55 95%CI 1.17–2.07). This association was strengthened when considering only polyps larger than 10 mm (OR 3.40 95%CI 2.29–5.04) detected on the index examination. A poor preparation (compared to a fair preparation) was also associated with an early repeat colonoscopy (OR 2.62 95%CI 2.03–3.37). Comparing individual endoscopists, there was wide variability in the rate of early repeat colonoscopy for suboptimal preparation, ranging from 0% to 35% (Mean 19%, SD 9.9); provider was a significant covariate in the multivariate analysis ($p<0.0001$).

Sensitivity analysis

When early repeat colonoscopy was defined as a procedure performed within one year of the index examination, 269 (9%) of the 3,047 patients fulfilled this criterion. On multivariate analysis, the associations of depth of insertion, fellow participation, poor preparation, and polyps with an early repeat examination remained significant (data not shown). However, clinical indication was not associated with an repeat colonoscopy within one year (OR for surveillance colonoscopy 1.43 95%CI 0.91–2.26; OR for diagnostic colonoscopy 1.39 95%CI 0.93–2.07).

Adenoma miss rates

Adenoma miss rates were calculated among 216 patients who had a suboptimally prepared colonoscopy followed by an optimally prepared complete colonoscopy with removal of all visualized polyps on the first examination (see Figure). The following patients were excluded from the 505 patients with suboptimal preparation whose colonoscopies were repeated: 115 patients with incomplete colonoscopy on index or repeat examination; 75 patients with polyps identified on the index examination but not removed or removed in piecemeal fashion; and 99 patients with a suboptimal preparation on the second colonoscopy.

Of the 216 patients, 44 (20%) underwent repeat colonoscopy between 2 and 3 years of the index examination, 86 (40%) underwent colonoscopy between 1 and 2 years of the index examination, and another 86 (40%) underwent colonoscopy within 1 year of the index examination. Of the 86 patients whose colonoscopy was repeated within 1 year, 61 (71%) patients underwent repeat colonoscopy within 6 months, including 45 within 3 months, 20 within 1 month, and 7 within 1 week.

Adenoma miss rates are listed in Table 3. Of the 198 adenomas removed, 83 (42%) were identified only on the repeat examination. The adenoma miss rate for lesions <10 mm in size (47%) was greater than the miss rate for lesions ≥10 mm (27%, $p=0.026$). The overall miss rate for suboptimally prepared colonoscopy was 42% (95%CI 35–49) for all adenomas and 27% (95%CI 17–41) for advanced adenomas. When restricting the analysis to those repeated examinations in which the index colonoscopy was for screening purposes in asymptomatic individuals ($n=72$), of 90 adenomas removed, 39 (43%) were identified only on the repeat examination. This subgroup analysis of screening examinations yielded an adenoma miss rate of 43% (95%CI 34–54) and an advanced adenoma miss rate of 37% (95% CI 22–56).

Adenomas proximal to the splenic flexure comprised 61% of all adenomas on the index colonoscopy and 60% of the adenomas on the second colonoscopy (Table 3). The adenoma miss rate was the same for proximal and distal lesions (42%, $p=0.95$). The adenoma miss rate for examinations in which the index preparation was poor was 49%, as compared to 38% if the index examination was fair ($p=0.19$). This non-statistically significant difference was driven by the miss rates for adenomas <10 mm in size (Poor: 56% vs. Fair: 42%, $p=0.15$), whereas the miss rates for adenomas ≥10mm was similar (Poor: 29% vs. Fair 26%, $p=1.0$).

Adenoma miss rates per patient are listed in Table 4. 55/216 patients (25%) had an adenoma identified on the repeat examination undetected on the index examination. At least one adenoma was identified in 74 patients (34%) on the index examination with at least one additional adenoma noted on the repeat colonoscopy among 27/74 individuals (36%). This miss rate was significantly greater than that for patients who did not have an adenoma noted on the index examination (20%, $p=0.012$).

When analyzing colonoscopies repeated within one year ($n=86$), the overall adenoma and advanced adenoma miss rates were 35% and 36% respectively. 19/86 (22%) had at least one additional adenoma detected on colonoscopy performed within one year. Similar to the overall analysis, the per-patient miss rate was greater among those with an adenoma on the index examination (37%) than those without an adenoma (15%, $p=0.047$).

DISCUSSION

A minority of patients with a suboptimal preparation on colonoscopy underwent an early repeat colonoscopy within three years at our institution. The factors that strongly influenced the decision to repeat the examination early included failure of cecal intubation, whether the procedure was for CRC surveillance or diagnostic purposes, and whether the preparation on index examination was poor as opposed to fair. In addition, any polyp identified on index examination and trainee participation was also associated with an early repeat examination.

Adenoma miss rates in the context of suboptimal preparation are high; of all of the adenomas identified, 42% were discovered only during the repeat colonoscopy. The miss rate for advanced adenomas, while comparatively less, also remained high at 27%. This proportion remained similar after redefining an early repeat colonoscopy as occurring within one year of the index examination, suggesting a true miss rate rather than subsequent neoplasia. The miss rate was particularly high for those suboptimal colonoscopies in which any adenoma was found on the initial exam compared to none detected (36% versus 20%, $p=0.012$), while adenoma miss rates did not vary by location (proximal versus distal adenomas).

It is not clear when to recommend a repeat colonoscopy when the preparation is suboptimal. While there is relative uniformity in surveillance intervals when preparation is optimal, there is considerable variability when preparation is suboptimal.⁹ Some gastroenterologists advise

a prompt repeat of the colonoscopy arguing that a suboptimally prepared colonoscopy is an incomplete examination.¹⁴ Others believe that a suboptimal preparation may obscure small lesions and the exam should “count” but the interval for subsequent colonoscopy be shortened.⁹ Guidelines mandate that preparation quality be noted in the colonoscopy report and suggest that an adequate preparation is one where lesions ≥ 5 mm in diameter can be identified.¹⁵ Current guidelines do not prescribe a particular course of action when preparation quality is compromised but merely state that “some colonoscopies must be repeated at intervals shorter than those recommended” because of inadequate preparation.¹⁵

The present study provides novel information. To the best of our knowledge, there are no other studies that have determined adenoma miss rates secondary to suboptimal bowel preparation by utilizing repeat colonoscopy data from the same subjects. Additionally, we also provide insightful information as to which factors are associated with an early repeat colonoscopy after an initial suboptimal bowel preparation. This study also reveals that adenoma miss rates are inversely proportional to adenoma size. As one would expect, subcentimeter adenomas were missed nearly twice as often as adenomas ≥ 10 mm. Advanced adenomas went undetected 27% of the time in patients who had an optimal bowel preparation on repeat study. Given the increased premalignant potential of advanced adenomas, a suboptimal preparation may cause an unacceptably high failure rate at identifying these important lesions thereby compromising the effectiveness of colonoscopy.

Tandem colonoscopy studies reveal baseline adenoma miss rates when the bowel preparation is optimal.^{11–13} One pooled analysis of six such studies quantified the overall adenoma miss rate at 22%, ranging from 15% to 32%.¹² Miss rates for large (≥ 10 mm) or histologically advanced lesions were smaller in all cases at 2% (range 1% to 8%).¹² Inadequate preparation is often explicitly stated as an exclusion criterion^{13, 16} or in the setting of a tandem colonoscopy study the preparation quality is held constant between exams.

We found that the participation of a trainee is independently associated with the decision to repeat an examination early after suboptimal bowel preparation. There are several plausible explanations for this phenomenon. Attending physicians may be less confident of a trainee’s ability to identify adenomas in the setting of suboptimal preparation compared to their own ability. Alternatively, trainees themselves may be less secure in their own abilities, and may be more risk averse, preferring to repeat an examination when the original colonoscopy was not optimally prepared. Lastly, trainee cases by definition involve more health care providers, a structure that may, by its nature, favor action as opposed to expectant management in the face of uncertainty. The findings in two recent studies^{17–18} that trainee participation is associated with increased adenoma detection suggest that, for reasons that remain speculative, participation of a trainee alters the dynamic of colonoscopy, resulting in increased efficacy.

There are several limitations to this analysis. The generalizability of our findings is uncertain as it is a single-center study. There was heterogeneity of clinical indications for colonoscopy which was not restricted to first-time screening examinations, similar to tandem colonoscopy studies.^{11–13} Secondly, selection bias may have impacted the calculated adenoma miss rates, as the majority of individuals with suboptimal preparation (83%) did not undergo early repeat colonoscopy. The adenoma miss rates of those patients who did not have a repeat colonoscopy after suboptimal preparation are unknown. Thirdly, the definition of an early repeat examination as that performed within 3 years may not reflect the intent to repeat due to suboptimal bowel preparation but rather the inappropriate recommendation by some gastroenterologists to offer surveillance examination regardless of bowel preparation.¹⁹ To address these limitations, we employed a sensitivity analysis with a

more stringent definition of early repeat colonoscopy occurring within one year of the index colonoscopy. The adenoma miss rates were unchanged and were substantially higher than those rates reported in tandem colonoscopy studies.

We conclude that a minority of patients undergo an early repeat examination after a suboptimally prepared colonoscopy, and that there is wide variation between physicians with regard to the decision to repeat a colonoscopy early in this setting. Our findings of a miss rate of 42% for all adenomas and 27% for advanced adenomas suggest that suboptimal bowel preparation has a substantial deleterious impact on the effectiveness of colonoscopy, and follow-up examination within one year should be considered. As neoplastic findings on the index colonoscopy were associated with a greater miss rate, a repeat examination within one year is indicated when an adenoma is found during a suboptimally prepared colonoscopy.

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Acronyms

CRC Colorectal cancer

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Figure.
Flow chart of adenoma miss rate analysis

Table 1

Characteristics of patients with suboptimal bowel preparation on colonoscopy, with comparison of those with early repeat examination (n=505) to those who did not have an early repeat examination (n=2542).

Characteristic	All patients (%)	Early repeat (%)	No early repeat (%)	p value
Total	3047	505 (17)	2542 (83)	
Age (years)				0.0004
<50	379 (12)	48 (13)	331 (87)	
50–59	895 (29)	118 (13)	777 (87)	
60–69	868 (28)	168 (19)	700 (81)	
70–79	658 (22)	127 (19)	531 (81)	
≥80	247 (8)	44 (18)	203 (82)	
Gender				0.7793
Male	1479 (49)	248 (17)	1231 (83)	
Female	1568 (51)	257 (16)	1311 (84)	
Location				0.0033
Inpatient	333 (11)	74 (22)	259 (78)	
Outpatient	2714 (89)	431 (16)	2283 (84)	
Depth of insertion*				<0.0001
Cecum/ileum	2797 (92)	405(15)	2392 (85)	
Did not reach cecum	246 (8)	100 (41)	146 (59)	
Trainee participation				<0.0001
Fellow	882 (29)	183 (21)	699 (79)	
No fellow	2165 (71)	322 (15)	1843 (85)	
Indication*				<0.0001
Screening	1354 (45)	155 (11)	1199 (89)	
Surveillance	609 (20)	172 (28)	437 (72)	
Diagnostic	1069 (35)	173 (16)	896 (84)	
Preparation				<0.0001
Fair	2158 (71)	254 (12)	1904 (88)	
Poor	889 (29)	251 (28)	638 (72)	
Findings				<0.0001
No polyp	1964 (64)	259 (13)	1705 (87)	
Any polyp	1083 (36)	246 (23)	837 (77)	
Polyp ≥10 mm	235 (8)	100 (43)	135 (57)	

* Sums do not add up to the total sample size due to missing data values.

Table 2

Multivariate analysis of factors associated with an early (<3 years) repeat colonoscopy among patients with a suboptimal preparation.

Characteristic	Odds Ratio	95% Confidence Interval	p value
Age (years)			
<50	1.0	[reference]	
50–59	0.93	0.60–1.44	0.7340
60–69	1.31	0.86–2.00	0.2166
70–79	1.30	0.84–2.02	0.2419
≥80	0.86	0.49–1.50	0.5957
Gender			0.3433
Male	0.89	0.70–1.13	
Female	1.0	[reference]	
Location			0.3621
Inpatient	0.82	0.54–1.25	
Outpatient	1.0	[reference]	
Depth of insertion			<0.0001
Cecum/ileum	1.0	[reference]	
Did not reach cecum	3.62	2.50–5.24	
Trainee participation			0.0292
Fellow	1.41	1.04–1.93	
No fellow	1.0	[reference]	
Indication			
Screening	1.0	[reference]	
Surveillance	2.89	2.09–4.01	<0.0001
Diagnostic	1.52	1.11–2.08	0.0084
Preparation			<0.0001
Fair	1.0	[reference]	
Poor	2.62	2.03–3.37	
Findings			
No polyp	1.0	[reference]	
Any polyp	1.55	1.17–2.07	0.0025
Polyp ≥10 mm	3.40	2.29–5.04	<0.0001
Endoscopist*			<0.0001

* Odds ratios for individual endoscopists not shown.

Table 3

Adenoma miss rates for patients with suboptimal preparation and complete repeat colonoscopy within 3 years (n=216)

	First Exam	Second Exam	Miss rate (%)	95% CI
All adenomas	115	83	42	35–49
≤5 mm	59	54	48	39–57
6–9 mm	21	16	43	29–59
≥10 mm	35	13	27	17–41
Location				
Proximal	70	50	42	33–51
Distal	45	33	42	23–54
≥10 mm or advanced histologic features	37	14	27	17–41
Adenocarcinoma	5	0	0	--

Table 4

Miss rates per patient among those individuals with a suboptimal preparation followed by complete repeat colonoscopy within 3 years (n=216)

Number of adenomas on first exam	Number of patients (%)	Number of patients with ≥ 1 adenoma on second exam
0	142 (66)	28 (20)
≥ 1	74 (34)	27 (36)