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ORIGINAL ARTICLE

Retrospective Study

Split-dose bowel preparation improves adequacy of bowel preparation and gastroenterologists' adherence to National Colorectal Cancer Screening and Surveillance Guidelines

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Author contributions: Menees SB conducted the data collection, analysis, and interpretation, and wrote and revised the manuscript; Schoenfeld P designed the research; Menees SB performed the research; Kim HM analyzed the data; Menees SB, Kim HM, and Schoenfeld P both contributed to draft revision.

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Abstract

AIM

To quantify the impact of split-dose regimen on endoscopists' compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm).

METHODS

A retrospective chart review of all endoscopy reports was undertaken in average-risk individuals > 50 years old with a normal screening colonoscopy and 1-2 small polyps. Data were abstracted from two time periods, pre and post-split-dose bowel preparation institution. Main outcome measurements were recommendation for timing of repeat colonoscopy and bowel preparation quality. Bivariate analysis by χ^2 tests and Student's

t-tests were performed to assess differences between the two cohorts. Multivariable logistic regression was used with guideline consistent recommendations as the dependent variables and an indicator for 2011 cohort as the primary predictor.

RESULTS

Four thousand two hundred and twenty-five patients were included in the study; 47.0% (1987) prior to the institution of split dose bowel preparation, and 53.0% (2238) after the institution of split dose bowel preparation. Overall, 82.2% (n = 3472) of the colonoscopies were compliant with guideline recommendations, with a small but significantly increased compliance rate in year 2011 (83.7%) compared to year 2009 (80.4%, P = 0.005), corresponding to an unadjusted odds ratio of 1.25 (95%CI: 1.07-1.47; P = 0.005). Colonoscopies with either "Adequate" or "Excellent" had increased from 30.6% in year 2009 to 39.6% in year 2011 (P < 0.001). However, there was no significant difference in poor/inadequate category of bowel preparation as there was a mild increase from 4.6% in year 2009 to 5.1% in year 2011 (P = 0.50).

CONCLUSION

Split-dose bowel regimen increases endoscopists' compliance to guidelines in average-risk patients with normal colonoscopy or 1-2 small polyps.

Key words: Colorectal cancer screening; Bowel preparation; Colonoscopy; Average-risk

Core tip: We evaluated the impact of split-dose regimen on endoscopists' compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm). We retrospectively evaluated 4255 patients who underwent colonoscopy during two time periods, pre and post the institution of split-dose bowel preparation. We found that split-dose bowel regimen increased endoscopists' compliance to guidelines in average risk patients with normal colonoscopy or 1-2 small polyps. Additionally, bowel preparation quality with either "Adequate" or "Excellent" had increased between the two time periods.

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INTRODUCTION

National guidelines state that average-risk 50+-year-old individuals who have normal screening colonoscopy should get a repeat colonoscopy in 10 years. However, physician recommendations do not always comply with guidelines. Krist *et al*[1] reviewed whether endoscopists' recommendations for patients undergoing colonoscopy for all indications adhered to published guidelines for follow-up recommendations. In only 64.9% of all reports, the endoscopist specified when retesting should occur. Recommendations were consistent with current guidelines in 36.7% of cases. However, Krist *et al*[1] did not account for patient bowel preparation at the time of the procedure in determining guideline consistent recommendation. Based on our previous research, bowel preparation was the single most important factor determining compliance by endoscopists for follow-up colonoscopies[2]. Patients with fair bowel preparation were 18.0 times (95%CI: 12.0-28.0) more likely to have recommendations inconsistent with guidelines compared to patients with excellent/good preparations.

In addition to association with guideline inconsistent recommendations, suboptimal colonoscopy preparation reduces adenoma detection rates (ADRs) and is a risk factor for incomplete colonoscopy[3-5]. To reduce the incidence of suboptimal bowel preparation, research has focused on the timing of the bowel preparation dosing in relation to the colonoscopy. The split-dosing regimen, where patients take a portion of the laxative the evening prior to colonoscopy and the other half on the day of colonoscopy, improves the bowel preparation quality. Studies have consistently shown that split-dose regimen is superior to administration of preparation on the day or night before the colonoscopy[6]. As early as 2009, the American College of Gastroenterology colorectal cancer (CRC) screening guidelines recommended institution of split-dose bowel preparation[7]. However, adoption of the split-dose bowel preparation has lagged due to providers' concern of patient compliance[8,9].

New quality measures assessing physician adherence to guidelines have been instituted by the Centers for Medicare and Medicaid Services (CMS) through the Physician Quality Reporting System (PQRS). For the PQRS, participating endoscopists will report the frequency of recommending repeat colonoscopy in 10 years after a normal colonoscopy in an average-risk patient. For participation, endoscopists will receive a small bonus in Medicare payments. In 2014, failure to report this resulted in a reduction in Medicare payments. Beside this economic factor, it is essential to guide CMS on what is an acceptable compliance rate for this quality measure (the frequency of recommending repeat colonoscopy in 10 years after a normal colonoscopy in an average-risk patient) and continue to assess the impact of bowel preparation on physician recommendation, particularly with split-

Table 1 Utilized colonoscopy preparations

Bowel preparation	Diet and fluid instructions	Traditional dosing (night before)	Split dose-bowel preparation
PEG, HalfLytely, NuLYTELY, or TriLyte,	Clear liquid diet for lunch and dinner; Ingest other clear liquids between doses of laxative.	Take 8 oz. every 15 min until it is gone between 12 pm and 6 pm.	Between 5 pm and 6 pm the night before colonoscopy, drink one (8 oz.) glass of laxative and continue drinking one (8 oz). glass every 15 min until 2l (64 oz.) of the preparation solution is gone; Drink the final 2l (64 oz.) of prep solution 5 h before the patient needs to leave for the procedure.
MoviPrep,	Clear liquid diet for lunch and dinner; Ingest other clear liquids between doses of laxative.	Take 8 oz. every 15 min until it is gone between 12 pm and 6 pm.	Between 5 pm and 6 pm, begin drinking the preparation; The MoviPrep container is divided by 4 marks; Every 15 min drink the solution down to the next mark (about 8 oz.), until the full liter has been consumed; Over the course of the evening, drink an additional 0.5 L of clear liquids; The next day, drink the final liter (32 oz.) of preparation solution 5 h before the patient needs to leave for the procedure.
MiraLAX (PEG 3350) /Gatorade	Clear liquid diet for lunch and dinner; Ingest other clear liquids between doses of laxative.	Take 2 tablets of bisacodyl between 12 pm and 6 pm, 4 h later take 8 oz. of the MiraLAX/Gatrade mixed in 2 liters of Gatorade every 15 min until gone.	At 12 noon, take 2 Dulcolax tablets; Between 5 pm and 6 pm, drink one (8 oz.) glass of the Miralax/Gatorade solution and continue drinking one (8 oz.) glass every 15 min thereafter until half the mixture (32 oz.) is gone. The next day, drink the final liter (32 oz.) of preparation solution 5 h before the patient needs to leave for the procedure.
OsmoPrep	Clear liquid diet for lunch and dinner; Ingest other clear liquids between doses of laxative.	Take first set of 20 tablets between 12 noon and 6 pm; Take a dose of 4 tablets every 15 min with at least 8 ounces of clear liquid; The second set of 12 tablets was to be taken 10-16 h after in the same manner as described above.	Between 5 and 6 pm take 4 tablets with 8 oz. of any clear liquid every 15 min; The patient will take a total of 20 tablets and drink 40 oz. of clear liquids over a 1 h period. The next day, 5 h before the patient needs to leave for your procedure, take 4 tablets with 8 oz. of any clear liquid every 15 min; The patient will take a total of 12 tablets and drink 24 oz. of clear liquid over a 30-min period.

dose bowel preparation. We hypothesized that the institution of split-dosing bowel preparation will reduce recommendations inconsistent with guidelines for follow-up colonoscopies in patients with normal colonoscopy or 1-2 small polyps (< 10 mm). Therefore, the objective of this research was to quantify the impact of split-dose regimen on endoscopists' compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm).

MATERIALS AND METHODS

Study design

With Institutional Review Board approval, a retrospective comparative review of medical records from two time periods (pre and post institution of split-dose bowel regimen) was performed. Medical records of consecutive average-risk patients aged ≥ 50 years and undergoing colonoscopy for CRC screening in the outpatient setting between January 1, 2009 and December 31, 2009 (pre-implementation of split-dose bowel regimen) and between January 1, 2011 and December 31, 2011 (post-implementation of split-dose bowel regimen) were reviewed. Inclusion criteria were average-risk patients referred for CRC screening colonoscopy with none, 1, or 2 identified polyps. Subjects were excluded for the following reasons: concurrent gastrointestinal symptoms (*e.g.*, anemia, overt or obscure gastrointestinal (GI) blood loss, abdominal pain, diarrhea, unexplained weight loss); family history of CRC; personal history of CRC, colon polyps, hereditary CRC syndrome, or inflammatory bowel disease; detection of any colonic polyps, or incomplete colonoscopies (*i.e.*, failure to visualize the appendiceal orifice and cecum). Only colonoscopies performed by gastroenterologists that were present in both calendar years were included. Patients with follow-up recommendations for "Barium enema" or "Discontinue due to age" were also excluded.

Protocol for bowel preparation and definition of bowel preparation quality

Bowel preparation details are included in Table 1 for same day bowel preparation utilized in 2009 and split-dose bowel preparation utilized in 2011. Bowel preparation quality and other endoscopic data were reported *via* the ProVation Medical Systems v.42 and University of Michigan endoscopy sites, respectively. Endoscopists rated bowel preparation quality according to the percentage of colonic mucosa visualized during the colonoscopy based on the Aronchick score which

Table 2 Patient and procedure characteristics by study year: 2009 is prior to split dosing, and 2011 is after split dosing

Characteristic	2009 (n = 1987)	2011 (n = 2238)	Total (n = 4225)	P value[1]
Age, yr				
≤ 55	1096 (55.2)	1311 (58.6)	2407	< 0.001
55-65	606 (30.5)	674 (30.1)	1,280	
65-75	233 (11.7)	253 (11.3)	486	
≥ 75	52 (2.6)	0 (0)	52	
Female	1099 (55.3)	1182 (52.8)	2281	0.100
Race/ethnicity				
White or Hispanic	1652 (83.1)	1846 (82.5)	3498	< 0.001
Black	131 (6.6)	160 (7.1)	291	
Asian	128 (6.4)	129 (5.8)	257	
Other	20 (1.0)	100 (4.5)	120	
BMI (kg/m^2), mean (SD)	1871 (94.2)	2213 (98.9)	4084	0.610
Current narcotics[2] use				
Yes	131 (6.6)	163 (7.3)	294	0.360
No	1856 (93.4)	2066 (92.3)	3922	
Current TCA use				
Yes	47 (2.4)	31 (1.4)	78	0.020
No	1940 (97.6)	2198 (98.2)	4138	
Type II diabetes				
Yes	164 (8.3)	201 (9.0)	365	0.400
No	1823 (91.7)	2037 (91.0)	3860	
Bowel preparation quality				
Adequate or excellent	592 (30.6)	886 (39.6)	1478	< 0.001
Good	1044 (54.0)	1048 (46.9)	2092	
Fair	209 (10.8)	189 (8.5)	398	
Inadequate or poor	89 (4.6)	113 (5.1)	202	
Polyp presence				
Yes	745 (37.5)	807 (36.1)	1552	0.330
No	1242 (62.5)	1431 (63.9)	2673	
Preparation type				
8L PEG	5 (0.3)	17 (0.8)	22	< 0.001
MiraLAX/Gatorade	541 (28.3)	1228 (57.1)	1769	
4L PEG, GoLYTELY, NuLYTELY, Colyte, TriLyte	1015 (53.1)	771 (35.9)	1786	
Half-Lytely,Osmoprep, Moviprep, and others	352 (18.4)	133 (6.2)	485	
Preparation type				
MiraLAX/Gatorade	541 (28.3)	1228 (57.1)	1769	< 0.001
4L PEG, GoLYTELY, NuLYTELY, Colyte, TriLyte	1015 (53.1)	771 (35.9)	1786	
Half-Lytely, Osmoprep, Moviprep, and others	357 (18.7)	150 (7.0)	507	
GI fellow presence				
Yes	187 (9.4)	303 (13.5)	490	< 0.001
No	1800 (90.6)	1935 (86.5)	3735	

All values are n (%), unless otherwise specified. The total number of patients for each characteristic may not add to total (n = 4225) due to missing data. [1]From testing differences in the distribution of characteristics between years, based on t-test for continuous variables and χ^2 test for categorical variables; [2]Narcotics are opioids and their derivatives. Common narcotics include morphine, heroin, hydrocodone, oxycodone, methadone, and clonitazene. BMI: Body mass index; TCA: Tricyclic antidepressant.

has been previously validated: "Excellent": greater than 95% of mucosa visualized; "Good": 90%-95% of mucosa visualized; "Fair": 80%-90% of mucosa visualized; and "Poor": less than 80% of mucosal visualization. An endoscopist could also report bowel preparation quality as "Adequate" or "Inadequate" if they felt the preparation did or did not, respectively, allow for the detection of polyps 5 mm or larger[10].

Endoscopists' recommendation intervals

Data were abstracted from patient colonoscopy report forms, pathology report, and follow-up pathology letter for the endoscopists' recommendation for follow-up screening colonoscopy. Follow-up recommendations were determined by adherence to the American College of Gastroenterology 2009 guidelines[7]. Recommendations consistent with guidelines included follow-up in 10 years, follow-up in 5 to 10 years for 1-2 small adenomas (as determined by pathologists), or ⩽ 1 year if bowel preparation quality was rated poor or inadequate regardless of the number of polyps. Any deviations from these recommendations were considered inconsistent with guidelines. If no recommendation was given by the endoscopist, it was classified as inconsistent with guidelines.

Subject and procedure data

Data were collected from medical notes on subject demographic, clinical, and procedural factors. Demographics included age, gender, and race/ethnicity; clinical factors comprised body mass index (BMI), concurrent narcotics and tricyclic antidepressant (TCA)

Table 3 Adjusted odds ratios of guideline consistent recommendations in average-risk patients (n = 4023)

Characteristic	OR	*P* value	95%CI
Year 2011	1.25	0.010	(1.05, 1.47)
Age, yr			
⩽ 55	1.00		
55-65	0.80	0.020	(0.67, 0.97)
65-75	0.64	< 0.001	(0.50, 0.82)
⩾ 75	0.40	0.004	(0.21, 0.74)
Male	0.94	0.440	(0.79, 1.11)
Race/ethnicity			
White or Hispanic	1.00		
Black	0.90	0.520	(0.66, 1.24)
Asian	1.09	0.630	(0.76, 1.56)
Others	1.00	0.990	(0.61, 1.64)
BMI (kg/m^2)	0.99	0.100	(0.97, 1.00)
Current Narcotics[1] use	0.79	0.140	(0.59, 1.08)
Current TCA use	0.89	0.710	(0.50, 1.60)
Type II diabetes	0.68	0.006	(0.52, 0.89)
Polyp presence	2.29	< 0.001	(1.89, 2.77)
GI fellow presence	1.48	0.020	(1.06, 2.08)

[1]Narcotics are opioids and their derivatives; Common narcotics include morphine, heroin, hydrocodone, oxycodone, methadone, and clonitazene. BMI: Body mass index; TCA: Tricyclic antidepressant.

usage, and diabetic status. Colonoscopy procedure data were collected on type of bowel preparation agent used, whether a GI fellow participated, and procedure completion status. Specific endoscopist characteristics were not collected due to Institutional Review Board concerns of the ability to identify specific gastroenterologists with the collected information.

Statistical analysis

Recommendation appropriateness was determined as either consistent or inconsistent with guidelines as described above under Endoscopist Recommendation Intervals. Primary exposure variable of interest was the institution of split-dose bowel preparation, and thus was the year 2011 *vs* 2009. χ^2 tests and Student's *t*-tests were used to assess differences in various demographic and procedure characteristics between 2009 *vs* 2011 cohort. To test if the institution of split-dosing bowel preparation reduced the percent of follow-up recommendations consistent with guidelines in patients with normal colonoscopy, logistic regression was used with guideline consistent recommendations as the dependent variables and an indicator for 2011 cohort as the primary predictor. Other independent predictors of guideline consistent recommendations included age, sex, race, BMI, narcotics use, TCA use, diabetes, and procedure characteristics. Odds ratios (ORs) and 95% confidence intervals (CIs) were obtained from the logistic regression model parameter estimates. Statistical analyses were performed using Stata 13.1 (StataCorp LP, College Station, TX, United States)

RESULTS

A total of 4225 patients were included in the study, with 47.0% (1987) from year 2009 prior to the institution of split-dose bowel preparation, and 53.0% (2238) from year 2011 after the institution of split dose bowel preparation. Overall, 82.2% (n = 3472) of the colonoscopies were compliant with guideline recommendations, with a significantly higher compliance rate in year 2011 (83.7%) than in year 2009 (80.4%, P = 0.005), corresponding to an unadjusted OR of 1.25 (95%CI: 1.07-1.47; P = 0.005).

Patient and procedure characteristics are summarized by study year in Table 2. Patients from year 2011 tended to be younger than those from year 2009 (means of 55.5 *vs* 56.1, respectively), but the difference was significant because 0% of year 2011 patients were 75 year or older, while 2.6% (52 of 1987) of year 2009 patients were 75 years or older. Patients from the two years were also different with respect to other characteristics including race and tricyclic antidepressant use. Although the distribution of bowel preparation quality was significantly different between the two years, the difference was not in "Poor" or "Inadequate" bowl quality. Specifically, in colonoscopies with bowel preparation quality ratings noted using four-level quality ratings only, colonoscopies rated as "Excellent" increased from 26.5% in year 2009 to 37.8% in year 2011, while those rated as "Poor" increased only slightly from 2.8% in 2009 to 3.1% in 2011. Similarly, when the binary rating of "Adequate" was combined with "Excellent" and "Inadequate" combined with "Poor" for colonoscopies without the four-level bowel preparation quality noted, the percentage of colonoscopies with "Excellent" or "Adequate" bowel preparation increased from 30.6% in year 2009 to 39.6% in year 2011 (P < 0.001, from comparing "Excellent" or "Adequate" *vs* other quality ratings), while the percentage of "Poor" or "Inadequate" quality increased from 4.6% in year 2009 to 5.1% in year 2011 (P = 0.50). Thus, the split-dose preparation appears to have resulted in a higher percentage of excellent/adequate preparation quality by reductions in mid-quality colonoscopies, but made no significant difference in poor/inadequate category of bowel preparation. Another important shift between the two years was the higher rate of MiraLAX/Gatorade use as the bowel preparation type in 2011 compared with 2009 (57.1% *vs* 28.3%).

Year 2011 cohort remained more likely to give guideline consistent recommendations (OR = 1.25, Table 3) even after adjusting for age, gender, race, BMI, current narcotics use, TCA use, type Ⅱ diabetes, site, and presence of polyp. Increasing age was associated with significantly lower odds of guideline consistent recommendations, and patients with type Ⅱ diabetes was associated with 0.68 times lower (P = 0.005)

Table 4 Adjusted[1] odds ratios of guideline consistent recommendations in average-risk patients obtained from logistic regression models fit separately by each year

	2009 Before split-dosing			2011 After split-dosing		
	OR	*P* value	95%CI	OR	*P* value	95%CI
Prep quality						
Adequate or excellent	1.00					
Good	0.55	0.001	(0.38, 0.78)	0.44	< 0.001	(0.32, 0.61)
Fair	0.04	< 0.001	(0.03, 0.06)	0.06	< 0.001	(0.04, 0.09)
Inadequate or Poor	0.17	< 0.001	(0.09, 0.30)	0.08	< 0.001	(0.05, 0.13)
Bowel prep type						
MiraLAX/Gatorade	1.00			1.00		
4L PEG, GoLYTELY, NuLYTELY, Colyte, TriLyte	0.65	0.013	(0.46, 0.91)	1.10	0.485	(0.84, 1.45)
Half-Lytely, Osmoprep, Moviprep, and others	0.62	0.032	(0.41, 0.96)	0.70	0.134	(0.44, 1.12)

[1]Adjusted also for all variables listed under Table 3.

odds of guideline consistent recommendations. On the other hand, the participation of GI fellows (P = 0.02) or having a colonoscopy with one or two polyps (as determined by pathology) were associated with a significantly higher likelihood (P < 0.001) of guideline consistent recommendations.

Between the two years, in addition to the implementation of split-dosing, the primary exposure of interest, we found that both bowel quality and bowel preparation distributions have changed significantly. To assess if the increased compliance between the two years can be explained by changes in preparation quality (which we expected to be associated with split dosing), changes in preparation type, or both, we further adjusted the model with the bowel preparation quality and bowel preparation type. After further adjusting for bowel preparation quality, we no longer found compliance difference between the two years (OR = 1.12, 95%CI: 0.93-1.34, P = 0.25). In addition, compared with "Excellent" or "Adequate" quality, all other preparation quality ratings were associated with lower odds of compliant recommendations: the adjusted OR of compliance for "Good" preparation was 0.48 (P < 0.001), "Fair" was 0.05 (P < 0.001), and "Poor" or "Inadequate" was 0.11 (P < 0.001). Similarly, when bowel preparation type categories were added to the model, the difference between the two years in compliance was no longer significant (OR = 1.16, P = 0.10), although bowel preparation type was not statistically significant, either. Lastly, compliance difference between the two years was not significant (OR = 1.03, P = 0.76) when both preparation quality and preparation type were included.

In summary, from year 2009 to year 2011, a significant increase in guideline consistent recommendations was seen, a significant increase in "Excellent" or "Adequate" colonoscopies was seen, and a significant increase in the use of MiraLAX/Gatorade was seen. However, the significant increase in guideline consistent recommendations from year 2009 to 2011 was no longer significant after controlling for either bowel preparation quality or bowel preparation type. To explore further whether the changes in preparation quality or preparation type led to increased compliance, we also fit logistic regression models separately by year (Table 4). In both 2009 and 2011 colonoscopies, we found preparation quality to be an independent predictor of compliance whether adjusted for preparation type or not; however, preparation type was a significant predictor of compliance only in 2009 colonoscopies, prior to split-dosing. These results suggested that split dosing likely reduced any differences in preparation quality associated with preparation type and hence resulted in less difference in compliance.

DISCUSSION

In our analysis of CRC screening in average-risk patients, implementation of split-dose bowel preparation led to an increase in guideline consistent recommendation, as indicated by increased percentage of guideline consistent recommendations from year 2009 to year 2011. Both the unadjusted and covariate adjusted ORs indicated a significant increase in guideline consistent recommendation from the year before to after the implementation of split-dose preparation. Additionally, we also found an increase in the percentage of bowel preparations rated as "Excellent" in quality between years 2009 and 2011, and it appeared that split-dose preparation led to a decrease in the percentage of "Good" and "Fair" preparation, but not in "Poor" preparation. Further analyses showed that an increase in guideline compliant recommendations from year 2009 to 2011 was explained by increased "Excellent" bowel preparation or decreased "Good" or "Fair" preparation. We reached this conclusion from the findings that: (1) a significant increase in guideline consistent recommendations was seen from year 2009 colonoscopies to year 2011 colonoscopies; (2) a significant increase in "Excellent" or "Adequate" colonoscopies was seen from year 2009 to year 2011; and (3) the significant increase in guideline consistent recommendations from year 2009 to 2011 was no longer significant after controlling for bowel

preparation quality. Our study adds further support for the use of split-dose bowel regimen as it is now uniformly recommended to optimize bowel preparation for colonoscopy[7,11-13].

This study is unique as it is the first to look at endoscopists' recommendations as an outcome pre- and post-introduction of split-dose bowel preparation. Studies of physician post-colonoscopy recommendations have shown varying compliance to guidelines. A retrospective review of screening and surveillance colonoscopies demonstrated endoscopists' compliance in 81% of subjects based on pathology[14]. However, recommendations were only provided in 74% of their cohort. This study removed bowel preparation as a factor as poor or fair bowel preparation or lack of bowel preparation data was the exclusion criteria. These findings are markedly better than those of Krist *et al*[1], where recommendations were only provided in 64.9% of reports. In studies including bowel preparation in their investigation, uniform bowel preparation quality impacts the likelihood of endoscopists' guideline compliance. Ransohoff *et al*[15] found that follow-up recommendations in bowel preparations less than excellent were associated with shorter surveillance intervals for those with no polyps, small or medium adenomas. Additionally, Rex *et al*[16] demonstrated that imperfect bowel preparation led to a higher likelihood of patients to be brought back earlier than suggested or required by current practice standards (20% *vs* 12.5%, $P = 0.04$). Our study contributes data for future benchmarks for endoscopist compliance of guidelines in the real world, split-bowel preparation setting, as the CMS requires reporting of quality indicators through the PQRS.

Significant patient and procedural characteristics were associated with both a higher and lower likelihood of guideline-inconsistent follow-up recommendations. Two patient characteristics associated with a higher likelihood of guideline-inconsistent recommendations included increasing age and the co-morbidity of diabetes mellitus. Both characteristics are associated with CRC. Increasing age is the strongest non-modifiable risk factor for the development of CRC[17]. The likelihood of CRC begins to increase after age 40 with a peak incidence between the ages of 65-79. For diabetes mellitus, Larsson *et al*[18] performed a meta-analysis of more than 2.5 million patients that demonstrated a 30% increased risk of CRC relative to non-diabetic individuals. This finding was constant even when controlling for BMI and physical activity. This literature may explain the association for early repeat colonoscopy recommendations in patients with these characteristics. However, two procedural characteristics, finding 1-2 polyps regardless of pathology and having a GI fellow participate in the colonoscopy, were less likely to have guideline-inconsistent follow-up recommendations. Surveys of gastroenterologists have shown an improvement in guideline knowledge and agreement for follow-up recommendations for colonoscopies[19,20]. Saini *et al*[19] assessed gastroenterologists' knowledge of the 2003 guidelines for management of various polyps. At that time, only 63.6% knew the correct interval for two small adenomas, but also 28.8% of gastroenterologists disagreed with the guideline. In 2010, Shah *et al*[20] surveyed Veterans Affairs gastroenterologists' similar questions about the 2006 polyp surveillance guidelines. Ninety-five percent of gastroenterologists identified the correct 5-10 years interval for one 8 mm adenoma. In this cohort of GI doctors, only 7% of those who knew guidelines correctly would deviate from clinical guidelines in their clinical practice. With the finding of any type of polyp, our endoscopists are compliant and know the guidelines. Additionally, gastroenterology fellows participating in the colonoscopy reduced the likelihood of inconsistent guidelines. The influence would have to be on the procedure itself as the attending physician is responsible for the follow-up pathology letter. In the literature, GI trainees have been noted to have positive impact on adenoma detection rate with the hypothesis that longer withdrawal times increase the likelihood of polyp detection or having an additional person involved in the colonoscopy allows optimal visualization[21-23]. For our cohort, the fellows' presence may have allowed better visualization (possible more patience with stool clearance or as a reminder for guideline compliance).

Our study has several potential limitations. As this study was retrospective in nature, the preparation type, preparation quality documentation, and endoscopist recommendations were limited to the medical records. Furthermore, patients who were prescribed spilt-dose bowel regimen during the second time period may not have actually taken it as recommended. Another limitation is the lack of use of quality assessment tool training, such as the Boston Bowel Preparation Scale; however, the grading scale in Provation is based on the Aronchick scale[10,24]. Additionally, there may be variability amongst physician reporting of bowel preparation quality that is not able to be captured by the retrospective nature of this study. The generalizability of the study may be limited since it involved only procedures performed by academic physicians, although the study was conducted at outpatient ambulatory surgery centers and in-hospital academic medical centers.

In conclusion, our study demonstrates that besides increasing bowel preparation quality, split-dose bowel preparation also increases guideline consistent recommendations in average-risk patients with normal colonoscopy or 1-2 small polyps. Our data adds further justification for the routine use of split-dose bowel preparation in daily practice. Education about recent guideline recommendations and the need for split-dose bowel preparation should be continued.

ARTICLE HIGHLIGHTS

Research background

Split-dose bowel regimen is considered standard of care for bowel preparation in national guidelines. Since it improves bowel preparation quality, we should

see an increase in endoscopists' compliance to guidelines.

Research motivation

Split-dose bowel regimen is recommended in national guidelines for colonoscopy bowel preparation. There is no data on how institution of split-dose bowel preparation can maximize the proportion of patients with an "excellent" bowel preparation and quantify the impact of "excellent" bowel preparation on increasing the likelihood of recommending an appropriate interval for repeat screening/surveillance colonoscopies.

Research objectives

To examine the impact of split-dose regimen on endoscopists' compliance with guideline recommendations for timing of repeat colonoscopy in patients with normal colonoscopy or 1-2 small polyps (< 10 mm).

Research methods

We conducted this retrospective study of colonoscopies performed in average-risk individuals aged 50 years or greater from two time periods, pre and post-split bowel preparation institution. Only patients with normal or 1-2 small polyps were included. Primary and secondary outcome measurements included: recommendation for timing of repeat colonoscopy and bowel preparation quality. Bivariate analysis and multivariable logistic regression analysis were utilized to assess the impact of split-dosing bowel preparation on both physician follow-up recommendation and bowel preparation quality.

Research results

After the institution of split-dose bowel regimen, there was a small, but significant increase in physician compliance to guideline recommendations in patients with normal colonoscopy and 1-2 small polyps. This correlated to the increase in both excellent and adequate bowel preparation. There was no measurable change in the amount of patients who had poor/inadequate bowel preparation.

Research conclusions

In this current study, our research supports the use of split-dose bowel regimen to help optimize bowel preparation. Improvement of bowel preparation quality increases the likelihood of physician compliance for follow-up colonoscopy in patients with normal colonoscopy and 1-2 small polyps.

Research perspectives

This study supports the use of split-dose bowel regimen for colonoscopy bowel preparation. Our study also acquired information on endoscopist compliance to CRC screening guidelines after the implementation of split-dose preparation in order to provide a new baseline for comparison. Improvement in endoscopist compliance can help make colonoscopy more cost-effective. It is crucial for endoscopists to abide by current guidelines, as recommending earlier colonoscopies not only exposes patients to excess procedural risk, but also drains limited resources that could be used for unscreened patients. This study provides pilot data for future endoscopist-based interventions.

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