

Usefulness of Personal Bowel Habits as a Predictive Factor for Inadequate Bowel Preparation for Colonoscopy: A Prospective Questionnaire-Based Observational Study

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Background/Aims: The quality of bowel preparation is important for optimal colonoscopy. It is influenced by medical and personal factors. We aimed to evaluate the effect of bowel habit on the quality of bowel preparation and to identify predictors of inadequate bowel preparation among bowel habit factors. **Methods:** From June 2017 to September 2017, 90 volunteers were enrolled in this study. Each participant answered a questionnaire consisting of multiple questions about personal bowel habits, including stool form, frequency of bowel movements per week, duration, and degree of straining for bowel movement. Then, all volunteers underwent colonoscopic exam. Eleven endoscopists performed colonoscopies and used the Boston Bowel Preparation Scale (BBPS) as the index for bowel preparation. Two expert endoscopists simultaneously reviewed all colonoscopic images to confirm the final BBPS. Univariate and multivariate logistic regression analyses were performed to verify the correlation between bowel preparation adequacy and bowel habit. **Results:** Among the 90 participants, 20 (22.2%) had inadequate bowel preparation (total BBPS ≤ 6 or any segmental BBPS ≤ 1). In univariate analysis, infrequent bowel movement (0–2/week) (odds ratio [OR], 12.60; 95% confidence interval [CI], 1.22 to 129, $p=0.03$) and moderate straining (more than 1/4 of defecations) (OR, 4.40; 95% CI, 1.44 to 13.39; $p=0.01$) were significantly associated with inadequate bowel preparation. However, only moderate straining was significantly associated with inadequate bowel preparation in multivariate analysis (OR, 3.99; 95% CI, 1.26 to 12.65; $p=0.02$). **Conclusions:** Straining is a significant predictor for inadequate bowel preparation. For patients with straining during bowel movements, an intensified preparation regimen should be considered. (*Gut Liver* 2019;13:169-175)

Key Words: Defecation; Bowel preparation; Constipation; Colonoscopy

INTRODUCTION

Colonoscopy is essential for colorectal cancer screening. Adenomatous polyp is a precursor of colorectal cancer. Colonoscopy has been approved as an effective screening tool to prevent colorectal cancer because it is appropriate for detection and instant removal of polyps.^{1,2} Adequate bowel preparation is very important so that pathologic mucosal lesions will not be missed. Poor bowel preparation results in prolonged time for bowel cleansing, cecal intubation, and scope withdrawal. Such patients may need repeat examinations at earlier intervals, leading to higher healthcare costs.³⁻⁶

Inadequate bowel preparation has negative effect on adenoma detection rate, an independent risk factor for interval colon cancer and mortality.^{7,8} Well-known risk factors for suboptimal bowel preparation include constipation, diabetes, liver cirrhosis, previous history of abdomino-pelvic surgery, high-residual diet, medications lowering bowel transition such as opioids or tricyclic antidepressant, and obesity.^{4,9-12} Among these factors, constipation representing one's bowel habit is known to be associated with inadequate bowel preparation in many studies. However, almost all studies were performed retrospectively. In addition, they regarded constipation as a simple symptom based on patient's answer.

The definition of constipation is quite sophisticated. It is established by careful history taking. According to Rome IV guideline, diagnostic criteria for functional constipation (FC) include the following: infrequent bowel movements, moderate straining, hard stools with Bristol Stool Form Scale (BSFS) of 1 to 2, sensation of incomplete evacuation or anorectal obstruction.

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Received on May 25, 2018. Revised on August 2, 2018. Accepted on August 2, 2018. Published online January 3, 2019

pISSN 1976-2283 eISSN 2005-1212 <https://doi.org/10.5009/gnl18236>

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tion, and history of manual maneuvers.¹³ Among them, hard stool and infrequent bowel movement are known as factors correlated with inadequate bowel preparation. Recently, a prospective study has suggested that low BSFS is associated with inadequate bowel preparation and BSFS may be useful for screening patients at risk of inadequate bowel preparation.¹⁰ Another study has also suggested that infrequent bowel movement is significantly associated with inadequate bowel preparation.¹⁴ However, both studies did not deal with another component of constipation criteria.

The objective of this study was to evaluate the effect of personal bowel habit on the quality of bowel preparation using a well-designed questionnaire and identify predictors of inadequate bowel preparation among factors of bowel habit.

MATERIALS AND METHODS

1. Study population

We prospectively included outpatients aged 20 to 80 years who underwent scheduled colonoscopy at Samsung Medical Center (a tertiary-care hospital) from June 2017 to September 2017. Exclusion criteria were: those who had mechanical bowel obstruction, failed complete intake of bowel preparation agent, failed cecal intubation, previous history of small bowel or large bowel resection, and active inflammatory bowel disease (IBD). All patients were prescribed the same bowel preparation agent with same-day dosing regimen: low volume polyethylene glycol (PEG) solution (2 L) with ascorbic acid.

2. Study design

Before colonoscopy, all participants completed the questionnaire about their bowel habits. The questionnaire was made based on the Rome IV diagnostic criteria of FC. It contained four items: stool consistency, frequency of bowel movement per week, time required for bowel movement, and degree of strain during bowel movement. It also asked about whether restriction of diet before exam and the factors that might affect bowel movement such as comorbidities and medication history, especially constipation-inducible medication, such as opioids, amitriptyline, iron supplements, or sedatives. Among these items,

stool consistency was expressed by pictures of BSFS and hard stool consistency was defined as BSFS 1 or 2.

Before preceding the study, well-trained 11 endoscopists were educated about bowel preparation scale assessment using Boston Bowel Preparation Scale (BBPS) by watching video (www.cori.org/bbps) and discussion for example cases. After completion of colonoscopic exam, these study endoscopists assessed bowel preparation scale according to BBPS independently. Finally, two expert endoscopists (E.R.K. and N.Y.P.) who had performed over 1,000 cases of colonoscopy per year simultaneously reviewed all images of colonoscopy and confirmed the correct BBPS. Clinical data including age, sex, and medical history were collected by reviewing electronic medical chart.

The study protocol was reviewed and approved by the Institutional Review Board at Samsung Medical Center. Informed consent was obtained from each participant prior to this study (IRB file No. 2017-05-077-001).

3. Statistical analysis

The primary outcome was adequacy of bowel preparation. Participants were divided into two groups: adequate bowel preparation group and inadequate bowel preparation group. Inadequate bowel preparation was defined when total BBPS was equal to or less than six or any segmental BBPS was equal to or less than one.

Continuous variables are expressed as median and quartile while categorical variables are presented as numbers with percentages. Differences in characteristics between groups were analyzed using Pearson chi-square test or Fisher exact probability test. Univariate and multivariate binary logistic regression analyses were performed to identify predictors among factors of bowel habit in the questionnaire. In the setting with BBPS as a continuous variable, Mann-Whitney test was also performed to assess whether mean BBPS differed between two populations according to each factor in the questionnaire. Statistical analysis was executed using SAS version 9.4 (SAS Institute Inc, Cary, NC, USA) and $p < 0.05$ was considered statistically significant.

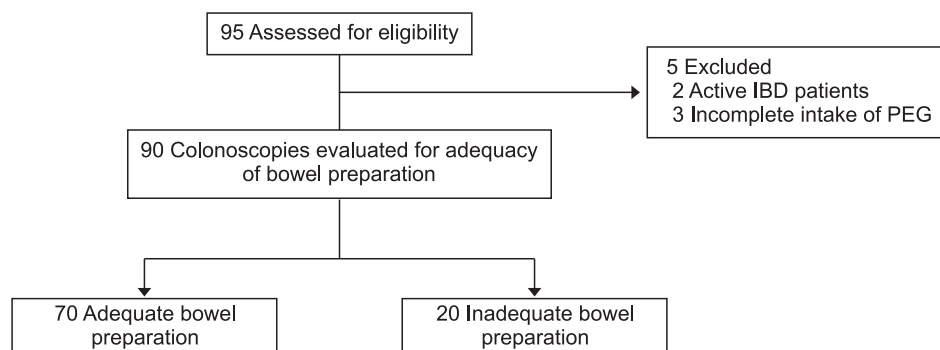


Fig. 1. Flowchart showing the selection of patients. IBD, inflammatory bowel disease; PEG, polyethylene glycol.

RESULTS

1. Baseline characteristics

Ninety-five eligible patients were enrolled in this study. Among them, five participants were excluded, including two active IBD patients and three who failed to take the bowel preparation agent. After exclusion, a total of 90 participants were included in the analysis (Fig. 1). The mean age of these participants was 57.4±13.8 years and 49 participants (54.4%) were males. Baseline characteristics of these participants are shown in Table 1. Seventy participants (77.8%) were categorized in the adequate bowel preparation group while 20 participants (22.2%)

were categorized in the inadequate bowel preparation group. There were no significant differences in age, proportion of male sex, percentage of diet restriction, medications, or history of abdomino-pelvic surgery between the two groups. Five participants (7.1%) in the adequate bowel preparation group and six participants (30.0%) in the inadequate bowel preparation group had diabetes. Indications for colonoscopies were mostly screening or surveillance and those were not significantly different between the two groups.

2. Predictors for inadequate bowel preparation

To evaluate the association between the adequacy of bowel

Table 1. Baseline Characteristics

Characteristics	Adequate bowel preparation (BBPS>6)	Inadequate bowel preparation (BBPS≤6 or segmental BBPS≤1)	p-value
No. of participants	70	20	-
Age, yr	59.5 (49.3–65.3)	59.0 (49.5–70.0)	0.207
Male sex	36 (51.4)	13 (65.0)	0.282
Restriction of diet	41 (45.5)	13 (65.0)	0.605
Comorbidities			
Diabetes	5 (7.1)	6 (30.0)	0.062
Chronic kidney disease	2 (2.8)	0	1.000
Parkinson's disease	0	0	-
Cerebrovascular disease	1 (1.4)	1 (5.0)	0.397
Depression	1 (1.4)	0	1.000
Hypothyroidism	0	1 (5.0)	0.222
Any malignancy	6 (8.5)	1 (5.0)	1.000
Medication use			0.264
Constipation-inducible	9 (12.8)	2 (10.0)	
Opioids	1 (1.4)	1 (5.0)	
Amitriptyline	1 (1.4)	0	
Iron supplements	2 (2.8)	0	
Sedatives	2 (2.8)	1 (5.0)	
Others*	3 (4.2)	0	
Laxatives	2 (2.8)	0	
Prokinetics	4 (5.7)	4 (20.0)	
History of abdominal or pelvic surgery	21 (30.0)	6 (30.0)	1.000
GI tract surgery	11 (15.7)	5 (25.0)	
Other abdominal surgery	6 (8.6)	0	
Pelvis surgery	4 (5.8)	1 (5.0)	
Indication for colonoscopy			-
Screening or surveillance	47 (67.1)	16 (90.0)	
Abdominal symptoms	12 (17.1)	4 (20.0)	
To rule out GI bleeding	9 (12.9)	0	
To follow up IBD	2 (2.9)	0	

Data are presented as median (quartile) or number (%).

BBPS, Boston Bowel Preparation Scale; GI, gastrointestinal; IBD, inflammatory bowel disease.

*Gabapentin, almagel, naproxen.

preparation and each factor of bowel habit in the questionnaire, univariate and multivariate logistic regression analyses were performed. Results are shown in Table 2. In univariate analysis, factors associated with inadequate bowel preparation were infrequent bowel movement (0–2/week) and moderate straining during bowel movement (more than 1/4 of defecations). Diabetes was associated with inadequate bowel preparation, although the association was not statistically significant (odds ratio [OR], 2.76; 95% confidence interval [CI], 0.88 to 8.59; $p=0.08$). In multivariate analysis including age, sex, diabetes, infrequent

bowel movement, and moderate straining, only moderate straining was significantly associated with inadequate bowel preparation (OR, 3.99; 95% CI, 1.26 to 12.65; $p<0.05$).

Participants who needed moderate straining during bowel movement or had infrequent bowel movement showed higher percentage of inadequate bowel preparation than those who did not (37.8% vs 11.3%, $p=0.021$; 66.7% vs 19.0, $p=0.003$, respectively) (Fig. 2).

Table 2. Univariate and Multivariate Binary Logistic Regression Analyses of Predictors for Inadequate Bowel Preparation, Including Each Questionnaire Index

Factors	Adequate bowel preparation (n=70)	Inadequate bowel preparation (n=20)	Univariate analysis		Multivariate analysis	
			Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age	-	-	1.01 (0.97–1.05)	0.59	1.02 (0.97–1.06)	0.44
Sex						
Female	34 (48.6)	7 (35.0)	0.57 (0.20–1.59)	0.29	0.81 (0.24–2.67)	0.72
Male	36 (51.4)	13 (65.0)	Reference		Reference	
Diabetes						0.24
Yes	6 (8.5)	5 (25.0)	2.76 (0.88–8.59)	0.08	2.59 (0.53–12.56)	
No	64 (91.4)	15 (75.0)	Reference		Reference	
Diet restriction					-	-
No	29 (41.4)	7 (35.0)	0.60 (0.20–1.80)	0.37		
3 Day before exam	41 (58.6)	13 (65.0)	Reference			
BSFS					-	-
1 or 2	8 (11.4)	5 (25.0)	2.57 (0.50–13.20)	0.26		
3 or 4	43 (61.4)	11 (55.0)	1.15 (0.31–4.17)	0.25		
5, 6, or 7	19 (27.2)	4 (20.0)	Reference			
Frequency of bowel movement per week				0.03		0.06
0–2/wk	2 (2.9)	4 (20.0)	12.60 (1.22–129)		6.15 (0.93–40.74)	
≥3/wk	68 (97.1)	16 (80.0)	Reference		Reference	
Time required for bowel movement				0.28	-	-
Longer than 3 min	26 (37.1)	11 (55.0)	1.78 (0.62–5.12)			
Shortly (≤3 min)	44 (62.8)	9 (45.0)	Reference			
Degree of strain during defecation (binary)				0.01		0.02
More than 1/4 of defecations (≥25%)	23 (32.8)	14 (70.0)	4.40 (1.44–13.39)		3.99 (1.26–12.65)	
Less than 1/4 of defecations (<25%)	47 (67.1)	6 (30.0)	Reference		Reference	
Degree of strain during defecation (tertiary)				0.01	-	-
>50%			31.33 (2.98–328.6)			
25%–50%			3.56 (1.15–11.04)			
<25%			Reference			
Any experience of commercial laxatives				0.49	-	-
Yes	8 (11.4)	3 (15.0)	1.87 (0.31–11.17)			
No	62 (88.5)	17 (85.0)	Reference			

Data are presented as number (%). Multivariable model including diabetes, frequency of bowel movements per week, and degree of straining during defecation.

OR, odds ratio; CI, confidence interval; BSFS, Bristol Stool Form Scale.

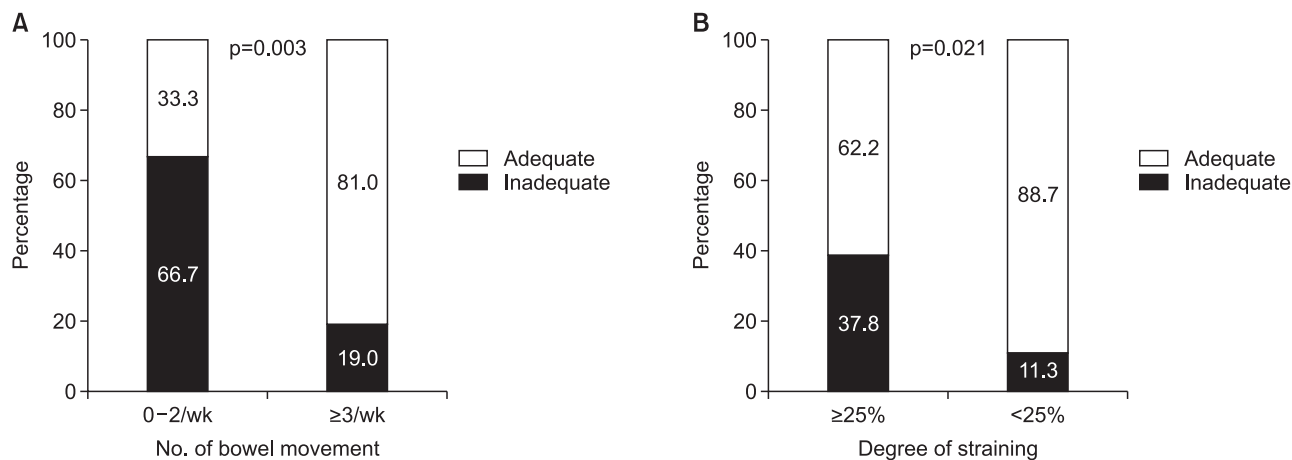


Fig. 2. A comparison of the proportion of participants showing inadequate bowel preparation according to each predictor. (A) Number of bowel movements per week. (B) Degree of straining.

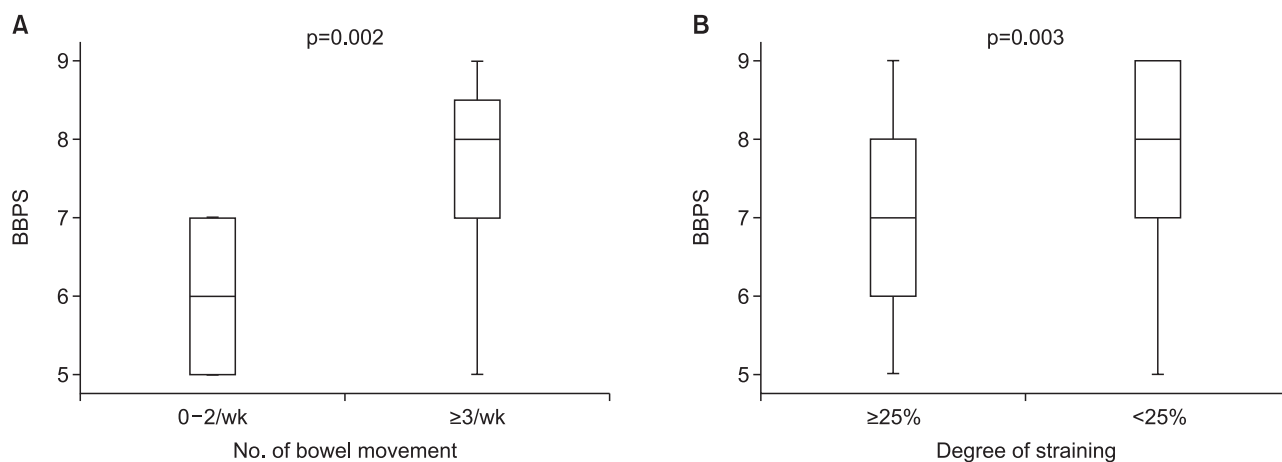


Fig. 3. A comparison of the distribution of Boston Bowel Preparation Scale (BBPS) according to each predictor. (A) Number of bowel movements per week. (B) Degree of straining.

3. Distribution of BBPS according to each predictor of inadequate bowel preparation

To evaluate the effect of each predictor of inadequate bowel preparation on BBPS, Mann-Whitney tests were performed. Results are displayed in box plot of BBPS distribution (Fig. 3). The distribution of BBPS was different among groups categorized by degree of straining and frequency of bowel movement per week. Median value of BBPS were lower in groups with moderate straining or infrequent bowel movement (median BBPS: 7 vs 8, $p=0.003$; 6 vs 8, $p=0.002$, respectively).

DISCUSSION

In this study, we prospectively evaluated the relationship between personal bowel habit and the quality of bowel preparation for colonoscopy. Moderate straining (more than 1/4 of defecations) and infrequent bowel movement (0-2/week) were

significantly associated with inadequate bowel preparation. However, age, female sex, and diabetes were not significant in this study, though they were well known as effective factors for inadequate bowel preparation. After multivariate analysis, only the degree of straining was a significant predictor of bowel preparation and had a proportional relationship with the score of BBPS. The more the straining, the poorer the bowel preparation. Our findings are consistent with those of previous studies showing that personal bowel habit is significantly associated with the adequacy of bowel preparation and constipation is one of the most effective factors of inadequate bowel preparation.^{4,9,15}

Constipation could result from decreased colonic transit. Stool form and stool frequency are useful surrogate markers for colonic transit.¹⁶ Hence, several studies have evaluated the relationship between stool form or stool frequency and bowel preparation quality. Malhotra *et al.*¹⁴ have prospectively studied 411 patients undergoing colonoscopy and showed that hard stool

with BSFS under three is closely related to inadequate bowel preparation. They also found that the use of the BSFS might identify suboptimal bowel preparation. However, their study did not check other components of bowel habit such as stool frequency or the degree of straining. Lee *et al.*¹⁰ have reported that infrequent bowel movement is a predictive factor of inadequate bowel preparation. However, the association between BSFS and bowel preparation was not significant in their study. Besides, they did not check up the degree of straining.

As a result, both studies could not perform multivariate analyses adjusting all factors of bowel habit. However, other previous studies have reported that the frequency of bowel movement has little association with bowel preparation.^{12,16} Therefore, effects of low BSFS and infrequent bowel movement on bowel preparation are controversial. Several previous studies have demonstrated an association between diabetes and inadequate bowel preparation.^{10,11} However, this present study could not verify the effect of diabetes on bowel preparation and it might be because of the small number of participants.

In this study, we surveyed personal bowel habit using more detailed questions in the questionnaire that was different from yes/no question about constipation in previous studies.¹⁰ To develop our questionnaire, two expert gastroenterologists reviewed the Rome IV criteria of FC and converted each criterion into questions with careful simplification. As a result, the questionnaire consisted of several questions asking the degree of straining, frequency of bowel movements, and stool form by BSFS as well as medical histories, diet restriction, and compliance to intake PEG solution. Among these questions, the degree of straining was the most significant factor that could predict the adequacy of one's bowel preparation. When we defined constipation according to the Rome IV criteria of FC based on participants' answers, constipation seemed to be associated with inadequate bowel preparation in univariate analysis, yet, it was not statistically significant (OR, 3.56; 95% CI, 0.96 to 13.22; $p=0.06$). This might be because of the portion of constipations defined by infrequent bowel movement and hard stool, except straining. This finding could reinforce our suggestion that the degree of straining is more predictable for inadequate bowel preparation than constipation.

According to our survey, some participants with infrequent bowel movement did not complaint straining or discomfort during defecation. Infrequent bowel movement may be normal if the number of times has not changed recently or defecation is not accompanied by discomfort.¹⁷ Furthermore, Saad *et al.*¹⁶ have reported that mean daily bowel movement frequency does not differ between constipated group and healthy group (1.0 and 1.1, respectively). For elderly patients, bowel movement frequency is sometimes overestimated if they have constipation with fecal incontinence.¹⁸ Hence, the frequency of bowel movements might be unreliable when it is measured without stool mass.

Stool form is also one of the core symptoms of constipation. Saad *et al.*¹⁶ have reported that stool form expressed by BSFS is useful to assess one's colonic transit and has modest correlation with colonic transit in chronic constipation. However, in our survey, there was modest discrepancy between BSFS and the degree of straining. Such discrepancy could be due to recalled bias of BSFS based on the tendency to recall more extreme forms than usual bowel habit.¹⁹ Furthermore, a meta-analysis have suggested that straining is the most common complaint of constipation rather than hard stool or infrequent bowel movement, especially in Asia (at 82.8%, 74.2% and 59.1%, respectively).²⁰ Therefore, straining rather than hard stool or infrequent bowel movement might be an important surrogate marker for constipation. Thus, the degree of straining needs to be assessed for one's bowel habit.

Based on our findings, we can propose the following recommendation. When a patient is scheduled for colonoscopy, physicians can ask the degree of straining, stool frequency, and stool form. By history taking, physicians can identify patients at risk of inadequate bowel preparation, thus considering more intensified bowel preparation regimen for them by adding prokinetics or prescribing large volume PEG.²¹

This study has some limitations. First, as clinical data of participants were collected using questionnaire, there might be recall bias and response bias. Second, although BBPS is well-validated by many studies, the reliability and reproducibility of BBPS are uncertain. In this study, differences of BBPS between performing endoscopists and review endoscopists were detected for 23 patients. Therefore, two expert endoscopists confirmed the final BBPS with consent of each other to ensure the objectivity of BBPS. Third, our data were small-sized without other factors such as body mass index, alcohol use, smoking, or waiting time for colonoscopy.

In conclusion, the degree of straining is the most significant factor that can predict bowel preparation quality. When straining is more severe, bowel preparation becomes poorer. By asking about the degree of straining, clinicians can identify patients at risk of inadequate bowel preparation. For these patients, a modified preparation regimen should be considered to achieve adequate bowel preparation. Further studies are required to verify the efficacy of intensified preparation regimen for these patients.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGEMENTS

Authors contributions: study design: E.R.K., N.P., and T.J.K.; statistical analysis: N.P. and E.R.K.; writing of the draft manu-

script: N.P. and E.R.K.; data collection: N.P., E.R.K., T.J.K., S.N.H., Y.H.K., and D.K.C.; critical revision of the manuscript: S.N.H., Y.H.K., and D.K.C. All authors approved the final submission.

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