Association Between Body-Mass Index and Quality of Split Bowel Preparation

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Abstract

Background and Aims—Little is known about the association between obesity and bowel preparation. We investigated whether body-mass index (BMI) is an independent risk factor for inadequate bowel preparation in patients who receive split preparation regimens.

Methods—We performed a retrospective study of data from 2163 consecutive patients (mean age, 60.6 ± 10.5 y; 93.8% male) who received outpatient colonoscopies in 2009 at the Veterans Affairs Medical Center in Indianapolis, Indiana. All received a split preparation, categorized as adequate (excellent or good, based on the Aronchick scale) or inadequate. We performed multivariable analysis to identify factors independently associated with inadequate preparation.

Results—Bowel preparation quality was inadequate for 44.2% of patients; these patients had significantly higher mean BMIs than patients with adequate preparation (31.2 ± 6.5 vs 29.8 ± 5.9, respectively; $P < .0001$) and Charlson comorbidity scores (1.5 ± 1.6 vs 1.1 ± 1.4; $P < .0001$). Independent risk factors for inadequate preparation were BMI ≥ 30 kg/m^2 (odds ratio [OR], 1.46; 95% confidence interval [CI], 1.21–1.75; $P < .0001$), use of tobacco (OR, 1.28; 95% CI, 1.07–1.54; $P = .0084$) or narcotics (OR, 1.28; 95% CI, 1.04–1.57; $P = .0179$), hypertension (OR, 1.30; 95% CI,

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1.07–1.57; *P*=.0085), diabetes (OR, 1.38; 95% CI, 1.12–1.69; *P*=.0021), and dementia (OR, 3.02; 95% CI, 1.22–7.49; *P*=.0169).

Conclusions—BMI is an independent factor associated with inadequate split bowel preparation for colonoscopy. Additional factors associated with quality of bowel preparation include diabetes, hypertension, dementia, and use of tobacco and narcotics. Patients with BMIs   30 kg/m^2 should be considered for more intensive preparation regimens.

Keywords

Colonoscopy preparation; colorectal cancer screening; overweight; adenoma detection

Introduction

Colonoscopy is a powerful tool for colorectal cancer (CRC) prevention, as it allows the detection and removal of precursor adenomatous polyps. The effectiveness of colonoscopy depends on several factors, foremost of which is the adequacy of visualization of the colonic mucosa, allowing a thorough inspection for colon neoplasms. Studies have shown that a poor bowel preparation is associated with lower adenoma detection rates (1, 2).

Despite the importance of preparation quality, there is no widely accepted definition of the precise characteristics of an adequate bowel preparation. The U.S. Multi-Society Task Force on Colorectal Cancer, and the ASGE/ACG Taskforce on Quality in Endoscopy state that an adequate preparation is one in which polyps >5 mm can be reliably visualized (3, 4). A 2010 meta-analysis showed that about 25% of patients do not achieve adequate preparation quality with polyethylene glycol-based bowel preparations (5). Tailored preparation regimens would certainly be beneficial in these patients, if they could be identified prior to their procedure.

Obesity is one risk factor among several that is associated with unsatisfactory bowel preparation (6), although whether this applies to split dose regimens is uncertain. Split dose preparations, where a portion of the preparation is given on the day of the examination, are essential for adequate preparation quality and have become the standard in clinical practice (7-9). Split-dose preparations increase the proportion of adequate preparation quality, increase patient compliance, and improve patient tolerance (10). Other variables associated with inadequate bowel preparation are male gender, older age, constipation, diabetes, dementia, history of stroke, liver cirrhosis, use of tricyclic agents and unfavorable socioeconomic conditions (11-15). However, it is also not clear if these risk factors are pertinent to split-dose preparations.

Our aim was to determine whether body-mass index (BMI) is an independent risk factor for inadequate preparation in patients who receive a split preparation regimen.

Materials and Methods

Population Description

This retrospective cross-sectional study was conducted at the Richard L. Roudebush Veterans Affairs Medical Center (VAMC) in Indianapolis, Indiana, a tertiary care academic VAMC affiliated with Indiana University. Consecutive patients who underwent colonoscopy between 1/1/2009 and 12/31/2009 were considered for inclusion. The study was approved by the Indiana University Institutional Review Board and the Roudebush VAMC Research and Development Board. Patients were identified by querying the VA computerized patient record system (CPRS). Subjects were eligible for inclusion if they underwent elective outpatient colonoscopy during the study period. In the event that a patient underwent more

than one colonoscopy, the first procedure only was included. Exclusion criteria consisted of patients with a prior colon resection; colonoscopies that were repeated within the study period due to prior poor bowel preparation; colonoscopies performed emergently, in hospitalized patients, after a two-day bowel preparation, or in underweight patients (BMI < 18.5 mg/m^2, as these patients may be more likely to have underlying physical or psychological comorbidities that could preclude successful completion of the preparation and introduce unknown confounders to the analysis); and incomplete colonoscopies for reasons other than inadequate preparation (cecum not reached due to factors not related to bowel preparation).

Bowel Preparation Description

All patients received a polyethylene glycol-based split bowel preparation. The standard bowel preparation was a split 4 liters of Colyte® (Alaven Pharmaceutical, Marietta, GA); 2 to 3 liters were consumed the evening prior to the procedure (along with 20 mg of Bisacodyl), and the remaining 1 to 2 liters were taken 4 hours prior to the colonoscopy. Two alternative split preparations were also used: MoviPrep® (Salix Pharmaceuticals, Raleigh, NC), with 1 liter consumed the evening prior to the exam, and the second liter 4 hours ahead of the colonoscopy; or MiraLax® (Merck, Whitehouse Station, NJ), with 119 g consumed the evening before the test (along with 10 mg of Bisacodyl) and another 119 g taken 4 hours before undergoing the colonoscopy.

Data Collection

The VA CPRS electronic medical records include demographic and clinical information. Our colonoscopy reports are generated using the Provation® system (Minneapolis, MN) and recorded in CPRS. Patient data collected included: demographic variables- age, gender, race, ethnicity, weight, height and BMI; comorbidities- coronary artery disease, congestive heart failure, diabetes mellitus, hypertension, stroke, dementia, liver cirrhosis, comorbidity count, and comorbidity burden using the Charlson comorbidity score (16); pertinent medication use- narcotics, calcium channel blockers, iron supplements, anticonvulsants and medications with anticholinergic properties (antispasmodics, antipsychotics, tricyclic agents and antiparkinsonian drugs); tobacco and alcohol use (excessive alcohol use was based on history of alcoholism, recurrent binge drinking or consuming regularly more than 2 drinks per day); and type of bowel preparation used. Colonoscopy data collected included: procedure indication, family history of colon cancer, bowel preparation type and quality, and findings. Preparation quality is subjectively assessed at our institution by each individual endoscopist according to the Aronchick scale: excellent, good, fair, poor and unsatisfactory (17). Colonoscopy findings recorded included presence of polyps, number, size, location and histology. The recommended follow-up colonoscopy interval was recorded, including whether the interval was shortened due to the preparation quality.

Statistical Analysis

Subjects were categorized based upon their colonoscopy preparation quality into two groups: adequate preparation (excellent or good preparation on the Aronchick scale) or inadequate preparation (fair, poor or unsatisfactory preparation). T-tests and Fisher's exact tests were used to compare both groups. BMI was categorized as normal (18.5 to 24.9 kg/m^2); overweight (BMI between 25 and 30 kg/m^2) or obese (BMI over 30 kg/m^2). Logistic regression was used to model the association of BMI with inadequate preparation quality, which was done treating BMI both as a continuous and a categorical variable. From each model, Receiver Operator Characteristics (ROC) curves were generated and area under the curve (AUC) was measured to help determine an optimal BMI cutoff. Multivariable logistic regression analysis was performed to determine factors independently associated with inadequate preparation quality, with candidate variables having univariate p-values <0.20.

Multivariable logistic regression was also used to obtain and compare estimates of the adenoma detection rate for adequate and inadequate preparation quality, after adjusting for the terms in the final model on inadequate preparation quality.

Results

During the study period, 3124 subjects underwent colonoscopy, of which 700 (22.4%) were excluded due to the following reasons: hospitalized status or emergent procedure (n=256; 36.6%), incomplete colonoscopy (unrelated to preparation) (n=21; 3.0%), repeat colonoscopy due to poor preparation earlier in 2009 (n=71; 10.1%), colonoscopy following a 2-day preparation (n=155; 22.1%), subjects not undergoing a split preparation (n=8; 1.1%), prior colon resection (n=168; 24.0%), and underweight (BMI < 18.5 kg/m^2) (n=21; 3.0%). An additional 261 were excluded due to preparation quality not documented in the colonoscopy report (n=41), unavailable BMI data (n=209), and incomplete medical records (n=11). Overall, 2163 subjects were included in the analysis. All colonoscopies were performed by one of seven staff endoscopists.

Basic Characteristics

Mean age of subjects in the study cohort was 60.6 ± 10.5 years; 93.8% were male; 82.5% were Caucasian. The mean Charlson score was 1.3 ± 1.5. Three hundred eighty-one patients (17.6%) had a normal BMI; 774 (35.8%) were overweight and 1008 (46.6%) were obese. Colonoscopy was performed for colorectal cancer screening in 746 patients (34.6%) and surveillance in 737 patients (34.1%); the remainder 675 cases (31.3%) were diagnostic colonoscopies, including 22 procedures performed to evaluate constipation (1.0%). Most patients received a split Colyte® preparation (n=1953; 91.1%); 45 subjects (2.1%) received MoviPrep® and 146 subjects (6.8%) received MiraLax® preparation.

Preparation quality was characterized as excellent in 26 subjects (1.2%), good in 1181 (54.6%), fair in 680 (31.4%), poor in 246 (11.4%), and unsatisfactory in 30 subjects (1.4%). When the preparation variable was dichotomized, there were 1207 subjects (55.8%) with adequate preparation quality and 956 (44.2%) with inadequate preparation quality. There was no statistically significant difference between the two groups for gender, race, ethnicity, family history of colorectal cancer, or bowel preparation type. There were minor differences between both groups for age, tobacco and alcohol use. The proportion of patients who were undergoing colonoscopy for diagnostic indications, was slightly higher in the inadequate preparation quality group (Table 1).

Univariate Analysis

Mean BMI in the group of patients with inadequate bowel preparation quality was significantly higher than in the adequate preparation quality group: 31.2 ± 6.5 kg/m^2 versus 29.8 ± 5.9 kg/m^2 (p<0.0001) (Table 1). Among subjects with inadequate bowel preparation quality, 53.0% were obese as compared with 41.5% of those with adequate preparation quality (p<0.0001). Subjects with inadequate bowel preparation quality also had significantly more comorbidities and a higher mean Charlson score compared to those with adequate preparation quality. When specific comorbidities were assessed, those with inadequate preparation quality had higher rates of coronary artery disease, congestive heart failure, diabetes, hypertension, and dementia. In addition, more subjects with inadequate preparation quality were using narcotics or calcium channel blockers (Table 2).

Univariate logistic regression found that obese patients had a significantly higher risk for inadequate preparation quality compared to both overweight subjects and normal BMI (Table 3). Similarly, BMI treated as a continuous variable was significantly associated with

inadequate preparation quality. Using a BMI cutoff point of 30 kg/m^2 maximizes the AUC at 0.558 (OR: 1.59; 95% CI: 1.34-1.89; p<0.0001).

Multivariate Results

Multivariable logistic regression analysis found that a BMI of   30 kg/m^2 was an independent risk factor for inadequate bowel preparation quality (OR: 1.46; 95% CI: 1.21-1.75; p<0.0001). In addition to BMI, hypertension, diabetes, dementia, tobacco use, and narcotics, were independent risk factors for inadequate bowel preparation quality (Table 4). The multivariate logistic regression analysis was run with and without preparation type (Colyte® vs MoviPrep® vs MiraLax®) in the model. Including the type of preparation taken by the patient in the model had no clinically important or statistically significant changes in the odds ratios for the independent variables.

Procedure Outcomes

There was no significant difference in polyp detection rate or adenoma detection rate (ADR) between the 2 groups (ADR 50.2% in the adequate preparation quality group, ADR 48.2% in the inadequate preparation quality group; p=0.35), after adjusting for BMI, tobacco and narcotics use, hypertension, diabetes and dementia. However, there was a significant impact of preparation quality on aborted procedures and follow-up intervals. No procedures (0%) were aborted in patients with adequate preparation quality, whereas 60 colonoscopies (6.3%) were aborted among those with inadequate preparation quality (p<0.0001). Further, the follow up colonoscopy interval was shortened specifically due to preparation quality in 6 patients with adequate preparation (0.5%) as compared with 554 patients (58.5%) with inadequate preparation quality (p<0.0001). Mean follow up interval was almost twice as long following an adequate preparation as compared to inadequate preparation quality: 56.7 ± 64.1 months vs 30.2 ± 48.2 months (p<0.0001).

Discussion

In this study, we found that obesity is an independent risk factor for inadequate bowel preparation quality in patients who receive split-dose regimens. A BMI   30 kg/m^2 was an independent risk factor for inadequate preparation quality. Independent of obesity, we also found that tobacco use, narcotic medications, hypertension, diabetes and dementia were associated with inadequate preparation.

Our results are consistent with previous studies that evaluated risk factors for inadequate preparation quality (6, 11-15, 18) (Table 5). Some variation is likely related to different study designs, study populations, definitions of inadequate preparation quality, and most importantly, the fact that our study is the first to strictly assess split-dose bowel preparation. An indication of constipation was found to be associated with increased likelihood of inadequate preparation quality in the study by Ness et al. (11), but not in our study, Lebwohl et al.'s (14) and Borg et al.'s (6) studies. Evaluating for most socioeconomic factors was not applicable to our study, as it was conducted at a VAMC; unmarried status and Medicaid insurance are the main socioeconomic predictors in other studies (14, 15). Similarly, we were not able to assess male gender as our cohort consisted largely of males. Consistent with our findings, Borg et al. (6) found that a BMI   30 kg/m^2 was an independent predictor of inadequate bowel preparation (OR 1.35; 95% CI: 1.09-1.68; p=0.006). In a recent Australian study, sodium picosulphate bowel preparation was prospectively assessed in 99 patients, 36% of whom were obese (19). There was no difference in good preparation quality between obese and non-obese patients (89% vs 90% respectively; p>0.99), and the authors concluded that a sodium picosulphate preparation is an excellent bowel preparation solution for obese patients.

Our study has several strengths. This is the first study where all included subjects received a split-dose bowel preparation. The sample in our study is large and the study population is homogeneous. The study was conducted in the VA system, which represents the largest single provider of healthcare in the United Sates, and the second largest payor for health services after Medicare.

Our study also has limitations. This study is retrospective in design, and 261 subjects (10.8%) were excluded due to relevant missing data. However, our final cohort included over 2000 subjects, and while we were unable to compare those excluded to the analyzed cohort, there is no reason to suspect that they would differ significantly. Our study is also a single center study from an academic VA medical center; thus, the generalizability of our results could be questioned, although they agree with the published literature in other populations. In addition, we recognize that the determination of preparation quality can vary significantly among endoscopists, particularly the definition of a fair preparation. Further, the colonoscopy reports did not routinely specify if preparation quality was ultimately documented based on the assessment preceding or following lavage and suction. While the use of the Boston bowel preparation scale (BBPS) has less interobserver variability (20), it is more cumbersome and reflects less the clinical practice compared to the Aronchick scale (17), which is used at our institution. Finally, the overall rate of inadequate preparation quality is higher in our study compared to other studies, reflecting some characteristics of our cohort, specifically, a strong male predominance and older age, and possibly due to the inclusion in the inadequate preparation group of fair preparations, a determination that is variable and subjective among endoscopists.

The effectiveness of colonoscopy depends largely on the quality of bowel preparation. In a recent study by Lebwohl et al., the adenoma miss rate due to suboptimal bowel preparation ranged between 35% and 42% (21). With an estimated 25% of patients or more not achieving adequate preparation quality for their colonoscopy (1, 5, 22), this represents a considerable barrier to optimizing colorectal cancer screening and surveillance, and a primary reason for aborting procedures and/or repeating them at a shorter interval that guidelines recommend (2, 23). The importance of an adequate bowel preparation quality in obese patients is particularly important, in light of the increasing incidence of obesity in the United States and worldwide, as well as the increased prevalence of colonic adenomas amongst obese patients, which was confirmed in two recent meta-analyses (24, 25). Recognizing other predictors of inadequate bowel preparation is similarly important, in order to tailor the preparation based on the assessment of all potential factors that could limit the success of a standard bowel preparation. A more intensive preparation regimen could be considered in patients with a BMI 30 kg/m^2. Measures to improve the preparation quality include a double dose of polyethylene glycol over 2 days, the choice of an alternative product, the addition of another cathartic, longer period of dietary restriction (low residue diet and clear liquid diet), as well as patient education endeavors to optimize understanding and compliance. According to a report by the Centers for Disease Control and Prevention (CDC), the burden of obesity on healthcare spending continues to increase, accounting for 9.1% of the annual medical spending in 2008 (about $147 billion dollars in a year) (26). Rex et al. have shown that imperfect bowel preparation increases colonoscopy costs by 12% to 22%, given aborted examinations, as well as completed examinations with suboptimal preparation requiring shortened follow up (27). Improving the effectiveness of colonoscopy in obese patients could contribute to reducing healthcare cost increments, by reducing the frequency of aborted and/or repeated procedures due to inadequate preparation quality, and importantly, by decreasing the incidence of colorectal cancer in obese patients.

In conclusion, BMI is an independent risk factor for inadequate colonoscopy preparation quality among patients using split bowel preparations. Diabetes, hypertension, dementia,

tobacco use and narcotic medications are additional risks factors that help identify patients who are also likely to require tailored preparations. A BMI 30 kg/m^2 should prompt consideration of a more intensive preparation regimen. Future efforts are necessary to establish and validate better preparation regimens, particularly in patients with high BMI and those with multiple predictors of unsatisfactory preparation. Improved bowel preparation results can lead to more rational and economical utilization of health care resources for prevention and early detection of colorectal cancer.

Acknowledgments

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Abbreviations

ADR	Adenoma Detection Rate
BMI	Body-Mass Index
CPRS	Computerized Patient Record System
CRC	Colorectal Cancer
VAMC	Veterans Affairs Medical Center

Table 1

Characteristics of Patients with Adequate and Inadequate Preparation Quality.

	All Subjects (n=2163)	Adequate Preparation Quality (n=1207)	Inadequate Preparation Quality (n=956)	p-value
Male gender, n (%)	2008 (93.8%)	1110 (93.0%)	898 (94.9%)	0.0701
Age (years), mean ± SD	60.6 ± 10.5	60.2 ± 10.8	61.1 ± 10.0	0.0430
Race, n (%)				0.3045
White	1587 (82.5%)	876 (81.7%)	711 (83.5%)	
Non-White	336 (17.5%)	196 (18.3%)	140 (16.5%)	
Hispanic, n (%)	12 (0.7%)	6 (0.6%)	6 (0.75%)	0.7749
BMI, n (%)				<0.0001
Normal	381 (17.6%)	233 (19.3%)	148 (15.5%)	
Overweight	774 (35.8%)	473 (39.2%)	301 (31.5%)	
Obese	1008 (46.6%)	501 (41.5%)	507 (53.0%)	
BMI (Kg/m^2), mean ± SD	30.4 ± 6.2	29.8 ± 5.9	31.2 ± 6.5	<0.0001
Tobacco Use, n (%)	848 (39.4%)	447 (37.2%)	401 (42.2%)	0.0209
Alcohol Use, n (%)				0.0297
Excessive	191 (8.9%)	105 (8.8%)	86 (9.1%)	
Social	704 (32.9%)	422 (35.3%)	282 (29.9%)	
No use	1244 (58.2%)	669 (55.9%)	575 (61.0%)	
Family history of CRC, n (%)	205 (9.6%)	119 (9.9%)	87 (9.2%)	0.6057
Colonoscopy Indication, n (%)				0.0209
Screening	746 (34.6%)	446 (37.0%)	300 (31.4%)	
Surveillance	737 (34.1%)	401 (33.3%)	336 (35.2%)	
Diagnostic	675 (31.3%)	357 (29.7%)	318 (33.4%)	
Constipation	*22 (1.0%)*	*11 (0.9%)*	*11 (1.2%)*	
Preparation Type, n (%)				0.5976
Colyte®	1953 (91.1%)	1098 (91.5%)	855 (90.6%)	
MoviPrep®	45 (2.1%)	26 (2.2%)	19 (2.0%)	
MiraLax®	146 (6.8%)	76 (6.3%)	70 (7.4%)	

SD, Standard Deviation; BMI, Body Mass Index; CRC, Colorectal Cancer

Table 2

Comorbidities and Medications Use in Patients with Adequate and Inadequate Preparation Quality.

	All Subjects (n=2163)	Adequate Preparation Quality (n=1207)	Inadequate Preparation Quality (n=956)	p-value
Comorbidities				
Coronary Artery Disease, n (%)	428 (20.3%)	209 (17.8%)	219 (23.5%)	0.0015
Congestive Heart Failure, n (%)	124 (5.9%)	58 (5.0%)	66 (7.1%)	0.0403
Diabetes, n (%)	638 (30.2%)	307 (26.0%)	331 (35.5%)	<0.0001
Hypertension, n (%)	1403 (65.5%)	737 (61.7%)	666 (70.3%)	<0.0001
Dementia, n (%)	27 (1.3%)	9 (0.8%)	18 (1.9%)	0.0198
Stroke, n (%)	100 (4.8%)	48 (4.1%)	52 (5.6%)	0.1217
Liver Cirrhosis, n (%)	53 (2.5%)	24 (2.1%)	29 (3.1%)	0.1247
Number of comorbidities, mean ± SD	1.0 ± 1.1	0.9 ± 1.1	1.2 ± 1.2	<0.0001
Charlson index, mean ± SD	1.3 ± 1.5	1.1 ± 1.4	1.5 ± 1.6	<0.0001
Pertinent Medications				
Narcotics, n (%)	556 (25.7%)	285 (23.6%)	271 (28.3%)	0.0132
Calcium Channel Blockers, n (%)	339 (15.7%)	170 (14.1%)	169 (17.7%)	0.0237
Anticholinergics, n (%)	428 (19.8%)	224 (18.6%)	204 (21.3%)	0.1151
Iron Supplements, n (%)	121 (5.6%)	64 (5.3%)	57 (6.0%)	0.5112
Anticonvulsants, n (%)	69 (3.2%)	31 (2.6%)	38 (4.0%)	0.0839

SD, Standard Deviation

Table 3

Univariate Logistic Regression of Association of BMI and Inadequate Bowel Preparation Quality.

	OR	95% CI	p-value
BMI (Kg/m^2)- continuous	1.04	1.02-1.05	<0.0001
Overweight vs Normal BMI	1.00	0.78-1.28	0.9887
Obese vs Normal BMI	1.59	1. 25-2.03	0.0001
Obese vs Overweight	1.59	1.32-1.92	<0.0001

OR, Odds Ratio; CI, Confidence Interval

Table 4

Independent Risk Factors for Inadequate Bowel Preparation Quality[*].

	OR	95% CI	p-value
BMI 30 Kg/m^2	1.46	1.21-1.75	<0.0001
Tobacco use	1.28	1.07-1.54	0.0084
Narcotics use	1.28	1.04-1.57	0.0179
Hypertension	1.30	1.07-1.57	0.0085
Diabetes	1.38	1.12-1.69	0.0021
Dementia	3.02	1.22-7.49	0.0169

OR, Odds Ratio; CI, Confidence Interval

[*] Results from final multivariable logistic regression model.

Table 5

Studies evaluating Risk Factors for Inadequate Bowel Preparation Quality.

Study-1st author, year	Study design	Country	No. of patients	Prep Type	Split prep (%)	Inadequate prep definition	Inadequate prep quality prevalence (%)	Independent risk factors for inadequate prep quality
Current study	Retrospective; Outpatients only	USA	2163	Polyethylene glycol, 100%	100	Aronchick scale: fair, poor or unsatisfactory	44.2	• BMI 30 Kg/m^2 • diabetes • hypertension • dementia • tobacco use • narcotic medications
Borg[6], 2009	Retrospective; Outpatients and Inpatients	USA	1588	• Polyethylene glycol, 87% • Sodium phosphate, 11.5%	Not described	Composite score: Aronchick scale + follow-up interval + adequacy of mucosa visualization	39.3	• BMI 25 kg/m^2 • BMI 30 kg/m^2 • diabetes • dementia • smoking • narcotic medications • antidepressants • no alcohol consumption • male gender • inpatient status
Ness[11], 2001	Prospective; Outpatients and Inpatients	USA	649	• Polyethylene glycol, 48.8% • Sodium phosphate, 51.2%	51.2 (all sodium phosphate preps)	Marginal (unsatisfactory visualization) or poor (unsatisfactory visualization + incomplete procedure)	21.7	• dementia • previous stroke • liver cirrhosis • constipation • tricyclic agents • male gender • inpatient status

Study-1st author, year	Study design	Country	No. of patients	Prep Type	Split prep (%)	Inadequate prep definition	Inadequate prep quality prevalence (%)	Independent risk factors for inadequate prep quality
Athreya[12], 2010	Prospective; Outpatients only: AM vs PM exam	Australia	325	Sodium picosulfate	46 (PM exam group)	Poor (solid and liquid washable stool), very poor (large stool amount or not washable) or aborted exam	N/A: scored for each colon segment separately	• constipation (specifically in the descending colon) • PM colonoscopies
Chung[13], 2009	Prospective; Outpatients and Inpatients	Korea	362	Polyethylene glycol, 100%	N/A: entire prep in AM on exam day	4-point scale (modified Aronchick scale): fair or poor	28.2	• diabetes • age > 60 • colorectal resection • appendectomy • hysterectomy
Lebwohl[14], 2010	Retrospective; Outpatients and Inpatients	USA	10921	Polyethylene glycol, "vast majority"	"vast majority NOT split"	Aronchick scale: fair or poor	21.9	• age > 60 • male gender • inpatient status • unmarried status • Medicaid insurance
Nguyen[15], 2010	Retrospective; Outpatients only	USA	300	Polyethylene glycol, 100%	Not described	No defined scale: inadequate or poor in report	15	• diabetes • 8 prescription drugs • older age • prior abdominal surgery • unmarried status • Medicaid insurance • interpreter requirement
Hassan[18], 2012	Prospective; Outpatients only	Italy	2811	• Polyethylene glycol, 75% • Sodium phosphate, 5%	12.3	4-point scale (modified Aronchick scale): fair or poor	33	• higher BMI • diabetes • liver cirrhosis • Parkinson disease • older age • male gender

Study-1st author, year	Study design	Country	No. of patients	Prep Type	Split prep (%)	Inadequate prep definition	Inadequate prep quality prevalence (%)	Independent risk factors for inadequate prep quality
				• Sennosides/other, 20%				• previous colorectal surgery

Prep, Bowel Preparation; N/A, Not Applicable