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Optimal Bowel Cleansing for Colonoscopy in the Elderly Patient

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Abstract

Colonoscopy is an important diagnostic and screening tool for colorectal cancer detection and prevention, and adequate bowel preparation is critical for successful colonoscopy. Complications related to colonoscopy are increased in elderly patients, either directly or indirectly related to the procedure, and the risks and benefits of colonoscopy procedures need to be carefully considered in these patients. Recent studies have shown that the 4 liter polyethylene glycol with a split preparation is safe and effective for elderly patients, and is the preferred preparation for patients with medical comorbidities. Preparations containing sodium phosphate are generally not recommended for the elderly due to increased renal complications. In addition, a low residue diet may aid in tolerance and willingness to undergo the procedure compared with a clear liquid diet, with comparable bowel preparation adequacy. Risk factors for inadequate bowel preparations include poor adherence to split preparation instructions or volume of solution ingested, and certain patient related medications and comorbidities, such as diabetes, elevated body mass index, and antidepressant or narcotic use. Methods for achieving safe and adequate bowel preparations in the elderly include clear instructions, reminder calls, and case management for potential confounding patient related factors.

Keywords

colonoscopy; bowel preparation; colon cancer screening

1. Introduction

Colorectal cancer is the third most common cancer diagnosed in both men and women within the United States. In 2016 it is estimated that there will be 95,270 new cases of colon cancer and 39,220 new cases of rectal cancer¹. Colonoscopy is an important diagnostic and screening tool for colorectal cancer detection and prevention, and adequate bowel preparation is critical for successful colonoscopy. Previous studies have shown that inadequate bowel preparation affects as many as 30% of all colonoscopy procedures in many U.S. facilities^{2–4}. The consequences of poor bowel preparation include reduced polyp detection rates, higher surgical complication rates, and procedure cancellations⁵. Poor bowel preparation presents a costly and unnecessary burden upon our health care system.

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Elderly patients (>age 65 years) deserve special consideration when planning a colonoscopy procedure. Complications related to colonoscopy are increased in elderly patients, either directly or indirectly related to the procedure. Complications related to bowel preparation regimens may also be increased in the elderly, due to increased incidence of comorbidities such as diabetes, congestive heart failure, and renal failure. Finally, the benefit of purely screening colonoscopy procedures is reduced in elderly patients and careful consideration of the risks and benefits is required prior to recommending colonoscopy. In this paper we will discuss issues specific to the elderly related to colonoscopy procedures, define optimal bowel cleansing, discuss the currently available preparations suitable for use in the elderly, and methods for improving adherence and outcomes in this patient group.

We searched the PubMed database between the dates of January 1, 2011 and December 1, 2016 for articles related to bowel preparation for colonoscopy with an emphasis on identifying review articles, practice guidelines, and key comparison studies. The keywords for the search were: colonoscopy, colon cancer screening, bowel preparation, split-dose, elderly patients, and polyethylene glycol. We also examined the literature referenced that was utilized for review articles. The purpose of this survey was to summarize the options available for patients today and the implications for elderly patients, rather than a systematic review of the primary literature.

2. Colonoscopy and the elderly patient

While the incidence of colorectal cancer increases with age, the benefits of screening are reduced after age 75 by competing morbidities. The current US Preventive Services Task Force (USPSTF) does not recommend routine colon cancer screening for all patients over the age of 75, but rather that “the decision to screen for colorectal cancer is an individual one,” and to evaluate the need for screening based on the patients overall health and risk factors. The USPSTF did not recommend any routine colorectal cancer screening for patients age 86 and above ⁶. Elderly patients with a prior history of colorectal neoplasia who are undergoing surveillance colonoscopies also have competing comorbidities that need to be taken into consideration when making decisions of whether to repeat these procedures. Tran, et al. performed a retrospective cohort study of 4834 elderly patients (age>75 years; 55.8% male)(median surveillance age, 79 years) and 22,929 individuals in the reference group (age 50–74 years; 57.7% male) (median surveillance age, 63 years) undergoing surveillance colonoscopy. They found that surveillance in the elderly was associated with a low incidence of CRC (0.24 per 1000 person-years vs 3.61 per 1000 person-years in the reference population ($P < .001$). After adjusting for comorbid illness, the elderly were found to have increased post procedure hospitalizations (OR 1.28 [95%CI, 1.07–1.53]; $P = .006$) ⁷. A Charlson score of 2 was also found to be independently associated with increased risk of post-procedure hospitalization. They noted that procedure related complications comprised only 13% of post-procedure hospitalizations, and exacerbation of underlying comorbid illness was a major indication for unplanned admissions (63.1%). These were not directly related to the procedure; however it is possible that exacerbation of underlying comorbidities was an indirect consequence of the invasive procedure. These data are similar to others who have noted increase risks related to colonoscopy procedures in the elderly. Kahi, et al. found in a cohort of US veteran patients that post-procedure mortality was increased among

patients older than 75 years and increasing Charlson score. Among patients age 80 years, the median survival was <5 years regardless of Charlson score⁸. Day, et al. reported a meta-analysis of 20 studies and found higher rates of cumulative gastrointestinal adverse events in patients 80 years (incidence rate ratio 1.7; 95% CI, 1.5–1.9) compared with patients less than 80 years⁹. Warren, et al, reported on a large cohort of elderly Medicare patients, and found that risks for adverse events after outpatient colonoscopy were low; however, they increased with age with specific comorbid conditions and depending on whether polypectomy was done¹⁰. They found that patients with a history of stroke, chronic obstructive pulmonary disease, atrial fibrillation, or congestive heart failure had significantly higher risk for serious gastrointestinal events following colonoscopy. Finally, a recent large population based prospective study of Medicare beneficiaries (n=1,355,692) at average risk for colorectal cancer found that the 8-year risk for colorectal cancer in 70–74 year old subjects was 2.19% in those who received colonoscopy and 2.62% in those who did not receive colonoscopy (absolute risk difference, –0.42% [CI, –0.24% to –0.63%])¹¹. In subjects aged 75–79 years the risk was 2.84% and 2.97%, respectively (risk difference, –0.14% [CI, –0.41 to 0.16]). They also found that the excess 30-day risk for any adverse events in the colonoscopy group was 5.6 events per 1000 individuals aged 70–74 and 10.3 events per 1000 individuals aged 75–79 years. Taken together, these studies support the recommendations of the US Preventive Services Task Force to stop colon cancer screening at age 75, and should be used to discuss the risks and benefits of any colonoscopy procedure in elderly patients, especially in those with comorbidities.

3. Definition of optimal bowel cleansing

Several rating systems are used by endoscopists to describe the quality of the bowel preparation achieved at the end of the procedure (Table 1). A widely used rating system is the Aronchick Bowel Preparation Scale because of the simplicity. The rating categories include: Excellent, Good, Fair, Inadequate, and Poor. Inadequate and poor ratings are generally equivalent and indicate that the colonoscopy was not successful. Other widely used and validated rating systems include the Boston Bowel Preparation Scale (BBPS), which rates the right and the left colon separately, The Ottawa Bowel Preparation Quality Scale, Chicago Bowel Preparation Scale, and the Harefield Cleansing Scale (HCS). Details pertaining to the scoring systems used in these scales are shown in Table 1. Parmar, et al. systematically reviewed the validity and reliability of 5 published and 2 preliminary bowel preparation scales and concluded that all the scales demonstrated a range of inter-observer reliability from fair to excellent, however the BBPS was the most thoroughly validated scale. In addition, the BBPS is recommended over the Aronchick and Ottawa classifications because it does not score for retained fluid and explicitly reflects the quality of the preparation after cleansing and suctioning efforts. Studies to date have demonstrated that high BBPS measurements have been associated with greater polyp detection, less repeat colonoscopies, and shorter insertion and withdrawal times¹².

An adequate bowel preparation is considered to be present if fine mucosal detail is visible in all portions of the colon such that the endoscopist is confident that small and flat polyps are detectable, and then recommends the standard screening or surveillance interval for a follow up procedure. The US Multi-Society Task Force on Colorectal Cancer and American Society

of Gastrointestinal Endoscopy has recommended that a preparation is adequate if after suctioning and washing the mucosa during the procedure it was deemed adequate for the detection of lesions greater than 5 mm in size¹³. Current practice suggests that any procedure with a preparation rating of less than excellent or good be accompanied by a recommendation for a shortened follow up interval¹⁴. There is no data currently available to suggest that a specific bowel preparation score is considered adequate, however a BBSP score of greater than 5 has been associated with a very low rate (2%) of shortened follow up intervals¹⁵.

4. Currently available bowel preparations

The currently available bowel preparations are listed in Table 2, along with representative comparison studies and their outcomes^{16–22}. Each preparation has its own risks and benefits¹⁵. The most common preparations include Polyethylene glycol (PEG) electrolyte lavage solution, which come as a 4 liter solution or a 2 liter solution that requires adjuvant treatments, or sodium phosphate (NaP) type laxatives. Concentrated preparations typically have a reduced volume allowing for improved compliance and readiness to repeat the procedure²³. The major drawback of the larger volume preparations is the volume required and the taste, however these are safer in regards to causing dehydration or electrolyte abnormalities (for a complete summary of the toxicities of all bowel preparations see Adamcewicz M, et al²⁴). In general, studies comparing different bowel preparations did not report differences in adenoma detection rates, and generally lacked the statistical power to make such a comparison.

Numerous physiologic changes are common in elderly patients, including decrements in renal function, reduced intestinal motility, along with the potential adverse effects of accumulating cardiovascular, neurologic, and other comorbidities with their need for concurrent medications^{25, 26}. For these reasons magnesium citrate should also be used with caution in the elderly, and has been associated with age-related increases in serum sodium, potassium, and urea, along with an increased risk for hypermagnesemia, with its resulting cardiac and neurologic complications^{24, 27}. In addition, elderly patients with cardiovascular disease may be predisposed to ischemic colitis, which is a reported rare complication of bisacodyl use²⁸. NaP regimens have been associated with renal damage from tubular toxicity from calcium phosphate. In general the use of NaP or other hyper or hypo-osmotic regimens in elderly patients with reduced renal function should be avoided. Current ASGE guidelines state that “there is insufficient evidence to recommend specific bowel preparation regimens for elderly persons; however, we recommend that NaP preparations be avoided in this population¹⁵.”

Efficacy of split bowel preparation

When using any bowel preparation it is essential that patients “split” the preparation. Numerous randomized controlled trials and meta-analysis of all studies comparing one time ingestion vs a split preparation conclude that the split dose is superior, and allows for increased adenoma detection, cecal intubation, and reduced insertion and withdrawal times^{29, 30}. Patients must be cautioned that the instructions on the product label do not call

for a split timing of ingestion. For the split preparation the patients are instructed to drink half of the volume over the course of an hour starting at 6PM the night prior to the procedure. On the day of the procedure, they are directed to finish the remaining volume approximately 4–6 hours prior to the start time of the colonoscopy. Additional instructions were given regarding drinking plenty of clear fluids and certain medications that should not be taken shortly before the procedure. The patients should then cease all oral intake 2 hours prior to the start time of the procedure. In general the patients are instructed to continue all their usual medications with the exception of diabetic medications. Patients who require chronic anticoagulation will need this discontinued at least 5 days prior to the procedure, and may or may not be required to using a bridging anticoagulant medication such as enoxaparin until the day of the procedure. Veitch et al. reports recent guidelines for patients on anticoagulation therapy preparing for an endoscopy procedure³¹. Patients who are reluctant to take a split prep in early morning hours can take the second portion before midnight, and will still have an improved preparation compared to patients who do not split the prep³², however this may decrease the efficacy compared to taking the second portion 4–6 hours before the planned start time of the procedure. Importantly for elderly patients, they should be reassured that studies have shown that there was no significant increased need for stopping to pass stool during trip to hospital following a split-preparation compared to evening-only preparation³³, and in a meta-analysis of multiple trials a split preparation was superior to an evening preparation for frequency of prep discontinuation (OR = 0.53; 95% CI: 0.28–0.98); willingness to repeat prep (OR = 1.76; 95% CI: 1.06–2.91), and the frequency of nausea (OR = 0.55; 95% CI: 0.38–0.79)³⁴.

Enestvedt et al performed a meta-analysis of randomized trials comparing a split dose 4 liter PEG preparation with other preparations including 4 L single dose PEG and low dose PEG and NaP split dose regimens with and without other additives such as ascorbic acid, tegaserod, lubiproston, bisacodyl, or magnesium citrate. In their review there were 9 relevant studies, and they found that the overall pooled odds ratio for excellent or good bowel preparation quality for 4-L split-dose PEG compared to other methods = 3.46 (95% confidence interval, 2.45–4.89; $P < .01$). In this study they found no significant differences between PEG and others in preparation compliance, favorable experience, willingness to repeat, abdominal cramping, nausea, or sleep disturbance¹⁶. They concluded that the gold standard bowel preparation method should be a split dose 4 liter PEG preparation. The addition of adjuvants such as bisacodyl, magnesium citrate or other medications to a split dose 4 liter PEG regimen was not studied.

Availability of alternative preparations

Several alternative preparations should be available to patients. A low volume preparation should be available to patients who have difficulty with the volume of a split 4 liter PEG preparation; however the presence of renal insufficiency and other co-morbidities must be taken into consideration. There is no consensus as to the best preparation for patients who are compliant but have inadequate results with a 4 liter PEG preparation. Patients who have failed a prior 4L split PEG regimen may require an extended low fiber (72 hours) and clear liquid diet (24 hours) two day regimen with repeating the split PEG regimen with the addition of 10 mg bisacodyl the evening before, as described³⁵. In our practice with patients

without renal failure (CrCL < 30ml/mn) who have previously failed a bowel preparation, we generally emphasize teaching related to the preparation and use a clear liquid diet beginning the day before the procedure and recommend a 4 L split PEG preparation with the addition of 1 bottle of magnesium citrate the evening before the procedure. For patients with renal failure we add an additional 2 L PEG to be taken the day prior to the procedure rather than using magnesium citrate. In addition, for patients complaining of bloating or nausea from the preparation, we recommend use a single dose of 20 mg metochlopramide orally prior to the ingestion of the PEG preparation²³. Note that metochlopramide should be avoided in patients with neurologic diseases and is not an effective overall adjunct that would warrant use in all patients³⁶.

Low residue versus clear liquid diet

Most studies to date have used a clear liquid diet for either 24 or 48 hours in addition to the bowel preparation solution or medication. Recently a meta-analysis of 9 randomized trials of low residue diets vs. clear liquid diets on the day prior to colonoscopy indicated that patients consuming low residue diet demonstrated significantly higher tolerability (OR 1.92; 95% CI, 1.36–2.70; $P < .01$) and willingness to repeat preparation (OR 1.86; 95% CI, 1.34–2.59; $P < .01$), with no differences in adequate bowel preparations (OR 1.21; 95% CI, 0.64–2.28; $P = .58$) or adverse effects (OR 0.88; 95% CI, 0.58–1.35; $P = .57$)³⁷. Low residue diets may include white bread, refined pastas and cereals, crackers, white rice, certain vegetables or fruits without skin or seeds, limited amounts of milk and yogurt, broth-based soups (strained) and sweets such as jelly, honey, and syrup. Further studies are needed in high risk groups to determine the adequacy of this diet.

5. Factors associated with poor bowel preparation

Table 3 summarizes risk factors associated with inadequate preparation from various multivariate analyses. Dik, et al. recently described an analysis of 1331 consecutive colonoscopy procedures at 4 centers, of which 172 (12.9%) had inadequate bowel preparations³⁸. The bowel preparation regimens in this study included split preparations using 4 liter PEG, 2 liter PEG + ascorbic acid, sodium picosulfate + magnesium citrate, or sodium phosphate. In a multivariate analysis the independent factors related to inadequate preparation the American Society of Anesthesiologists Physical Status Classification System score 3, use of tricyclic antidepressants, use of opioids, diabetes, chronic constipation, history of abdominal and/or pelvic surgery, history of inadequate bowel preparation, and current hospitalization. In this study increasing age, body weight, multiple medications, neurologic disease and cirrhosis were not associated with bowel preparation adequacy. Other studies have described other independent factors associated with inadequate bowel preparations, including elevated body mass index, older age, diabetes, Parkinson's disease, use of narcotics or antidepressants, hypertension, dementia, among others^{3, 4, 39–43} (Table 3). Further randomized studies are needed to study interventions that may improve upon current bowel preparation regimens in patients with characteristics indicating they are at high risk for inadequate preparations.

Many of the prior studies of patient-related risk factors for inadequate bowel preparations failed to take into account patient self-report of compliance with either splitting the preparation or the amount ingested. We recently used a prospective questionnaire given to patients presenting for a colonoscopy procedure to determine factors that correlated with inadequate bowel preparations⁴⁴. Data from the survey included patient compliance with the volume consumed (non-compliance defined as failure to complete at least 95% of the PEG solution), patient compliance with instructions adhere to the timing of the split preparation, self-reported difficulty level of the preparation, and the highest education level achieved by the patient. These data were supplemented by medical record data regarding gender, age, body mass index, distance from the medical clinic, current medications, mental health diagnoses, and other medical diagnoses. Of 500 consecutive patients, 87% (n = 435) had an adequate bowel preparation rating on their colonoscopies while 13% (n = 65) had an inadequate bowel preparation rating. In multivariate analysis, the most significant factor associated with inadequate bowel preparation was noncompliance with adherence to splitting the preparation [OR=2.99, 95% CI= (1.35, 6.63), p=0.01]. Ness et al⁴³, and Chan et al⁴⁰, also reported that non-adherence with instructions were highly related to inadequate preparations. These data indicate that patient education and instruction materials are of critical importance.

6. Methods for improving compliance and outcomes

Practice guidelines related to colonoscopy bowel preparations have been published by the US Multi-Society Task Force on Colorectal Cancer¹⁵. Full compliance to the instructions of the split-preparation plan has been shown to be a very important factor related to adequate bowel preparation. This has been observed in a multitude of prior bowel preparation studies that directly compared split preps with preps without split timing of ingestion. Therefore, methods that emphasize the importance of compliance with both the timing of ingestion of the preparation in addition to the entire volume of the preparation are important. This could be achieved by providing clear instructions and more education to the patients about their preparation as well as having health care professionals attentively follow-up on the patients to verify their understanding of the preparation process by performing pre-procedure calls. The use of patient navigators and enlisting the assistance of family members can be especially helpful in improving compliance in elderly patients. In addition, identification of patients who have failed previous bowel preparations is important in order to identify compliance issues and/or recommend a preparation with increased intensity. Table 4 lists specific evidence-based actions that can improve bowel preparation compliance⁴⁵, and we have made an effort to implement all of these at our institution. MacArther et al. have emphasized that there is no single intervention that is proven to be the most important for improving compliance, but rather practices should consider a number of different interventions that combined may be the most effective⁴⁶.

7. Conclusions

The quality of colonoscopy examinations is a crucial issue for any endoscopic procedure unit and health care system engaged in colon cancer screening programs. It is important to recognize that elderly patients have increased risks for complications from both colonoscopy

bowel preparations and procedures, and the risk-benefit balance for colonoscopy in elderly patients needs to be carefully considered. Overall a split 4 liter PEG split preparation is effective and preferred for elderly patients with comorbidities. We have provided recommendations for currently available bowel preparations and methods to improve the adherence and quality of the preparations. All centers should be engaged in continuous quality improvement efforts to improve bowel preparations, reduce the need for repeated procedures, and to minimize potential complications.

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Key Points

1. Complications are increased in the elderly and need to be considered along with expected benefits prior to recommending this procedure.
2. A split 4 liter polyethylene glycol preparation is highly effective and may be preferred for elderly patients with comorbidities.
3. Methods for achieving safe and adequate bowel preparations in the elderly include clear instructions, reminder calls, and case management for potential confounding patient related factors.

Table 1

Bowel preparation scoring systems (ref. 12)

Aronchick BPS	<p><u>Rating for entire colon</u> 5=Inadequate - repeat preparation needed 4=Poor - semi-solid stool could not be suctioned and <90% of mucosa seen 3=Fair - semi-solid stool could not be suctioned, but >90% of mucosa seen 2=Good - clear liquid covering up to 25% of mucosa, but >90% of mucosa seen 1=Excellent - >95% of mucosa seen</p>	Whole colon is scored.
Boston BPS	<p><u>Rating for each colon segment</u> 0=Unprepared colon segment with stool that cannot be cleared 1=Portion of mucosa in segment seen after cleaning, but other areas not seen because of retained material 2=Minor residual material after cleaning, but mucosa of segment generally well seen 3=Entire mucosa of segment well seen after cleaning</p>	Add scores of the right, transverse, and left colon segments. Ranges from 0 (very poor) to 9 (excellent)
Ottawa BPQS	<p><u>Rating for each colon segment</u> 4=Inadequate - solid stool not cleared with washing and suctioning 3=Poor - necessary to wash and suction to obtain a reasonable view 2=Fair - necessary to suction liquid to adequately view segment 1=Good - minimal turbid fluid in segment 0=Excellent - mucosal detail clearly visible <u>Rating for amount of fluid in colon</u> 2=Large amount of fluid 1= Moderate amount of fluid 0 = Small amount of fluid</p>	Add scores of the right, transverse/descending, sigmoid/rectum colon, and colon fluid. Ranges from 14 (very poor) to 0 (excellent).
Chicago BPS	<p><u>Rating for each colon segment</u> 0=Unprepared colon segment with stool that cannot be cleared (>15% of the mucosa not seen) 5=Portion of mucosa in segment seen after cleaning, but up to 15% of the mucosa not seen because of retained material 10=Minor residual material after cleaning, but mucosa of segment generally well seen 11=Entire mucosa of segment well seen after cleaning 12=Entire mucosa of segment well seen without washing (suctioning of liquid allowed) <u>Rating for amount of fluid in colon</u> 3=Large amount of fluid (>300 cc) 2=Moderate amount of fluid (151–300 cc) 1=Minimal amount of fluid (51–150 cc) 0=Little fluid (50 cc)</p>	Add scores of right, transverse, and left colon. Ranges from 0 (very poor) to 36 (outstanding). Fluid score is reported separately.
Harefield CS	<p>0=irremovable, heavy, hard stools 1=semi-solid only partially removable stools 2=brown liquid/fully removable semi-solid stools 3=clear liquid 4=empty and clean</p>	Rectum, sigmoid, descending, transverse, and ascending colon are rated 1–5. All scores are added (maximum 20). Then grade is determined as A, B, C, or D.

Table 2

Current colonoscopy bowel preparations

Solution	Polyethelene Glycol-electrolyte lavage solution (PEG)	Oral Sulfate Solution	Na Picosulfate/Mg Citrate (MC)	Sodium Phosphate	PEG-3350 powder + Gatorade	Magnesium Citrate (MC)	Other OTC products
Brand	Golytely, Colyte, GaviLyte, Nulytely	Suprep: OSS alone Suclear: PEG + OSS	Picolax, Picoprep, Prepopik, Picolax, Citrafleet, and Picolight	Fleet Phospho-Soda, Fleet EZ-Prep, Osmoprep	Miralax		Senna, Bisacodyl (often used as adjunct rx)
Volume	4L	32 oz	2L	90mL or Tablets (Osmoprep)	2L	600mL (lower volumes used with bisacodyl 10–20mg)	Tablets
FDA approved	Yes	Yes-split dose only	Yes	Yes	No	No	No
Risks	Hypokalemia in older patients	Caution w/electrolyte abnormalities	Avoid in renal disease-risk of hyper-magnesemia, electrolyte imbalance	Hyperosmotic-avoid in renal insufficiency, electrolyte abnormalities, CHF, cirrhosis, ascites. Black box for Acute Phosphate Nephropathy	Hypotonic Risk of hyponatremia;	Avoid in renal disease – risk of hyper-magnesemia, electrolyte imbalance	May have increased abdominal pain and cramping Bisacodyl rarely associated with ischemic colitis
Benefits	Preferred for renal insufficiency, congestive heart failure, advanced liver disease	Lower volume	Lower volume	Lower volume, well tolerated by most patients	Lower volume, well tolerated by most patients	Lower volume	Lower volume
Use in elderly	Preferred		Not recommended	Not recommended	Not recommended	Not recommended	
Outcome Reference	Enestvedt et al (16). In this meta-analysis of 9 higher-quality bowel preparation RCTs, 4-L split-dose PEG bowel preparation showed superiority	Rex et al (17) Successful bowel preparation was more frequent with OSS than with 4L PEG (98.4% vs 89.6%; P=.04).	Tan et al (22) Meta-analysis found Na picosulfate/MC to be superior to PEG-based regimens due to increased tolerability with comparable bowel cleansing	Schanz et al (18) Discomfort from ingested fluid was less in NaP group compared to PEG (39.8% vs 54.6%; P=.015).	McKenna et al. (19) PEG3350 + Gatorade gave higher overall satisfaction scores (p = 0.001), and had fewer adverse effects compared to PEG. ³⁰	Berkelhammer et al. (20) When preparations were taken the day before colonoscopy, MC achieved better bowel cleansing compared to NaP (p < 0.001).	Radaelli et al. (21) Overall cleansing was excellent/good in 90.6% of patients in the senna group and in 79.7% in the PEG group (p=0.003)

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Solution	Polyethelene Glycol- electrolyte lavage solution (PEG)	Oral Sulfate Solution	Na Picosulfate/Mg Citrate (MC)	Sodium Phosphate	PEG-3350 powder + Gatorade	Magnesium Citrate (MC)	Other OTC products
	over other bowel preparation comparators.						

Table 3

Independent risk factors for inadequate bowel preparations in multivariate analyses.

Author	N	Split Prep used?	Variable	OR (95% CI)
Dik et al. 2015	1331	yes	tricyclic antidepressants	5.3 (2.3–12.5)
			opiates	1.9 (1.0–3.6)
			diabetes	2.1 (1.3–3.4)
			chronic constipation	2.7 (1.7–4.3)
			prior abdominal/pelvic surgery	1.8 (1.3–2.6)
			prior inadequate prep	1.8 (1.1–3.0)
			current hospitalization	1.8 (1.0–3.1)
Fayad et al. 2013	2163	yes	BMI ≥ 30 kg/m ²	1.46 (1.21–1.75)
			tobacco	1.28 (1.07–1.54)
			narcotics	1.28 (1.04–1.57)
			hypertension	1.30 (1.07–1.57)
			diabetes	1.38 (1.12–1.69)
			dementia	3.02 (1.22–7.49)
Hassan et al. 2012	2811	Only for 12%	male	1.2 (1.02–1.5)
			high BMI	1.1 (1.03–1.1)
			older age	1.01 (1.004–1.02)
			prior colorectal surgery	1.6 (1.2–2.2)
			cirrhosis	5.0 (2.6–10.4)
			Parkinson disease	3.2 (1.2–9.3)
			diabetes	1.8 (1.3–2.5)
			positive FOBT	0.6 (0.5–0.8)
Borg et al. 2009	1588	no	BMI ≥ 25	1.28 (1.01–1.61)
Chan et al. 2011	501	3 day prep w/bisacodyl and low-residue diet followed by 2L PEG	Lower education level	2.35 (1.54 – 3.60)
			appt waiting time > 16 wks	1.86 (1.04 – 3.37)
			non-adherence to prep instructions	4.76 (3.00 – 7.55)
Chung et al. 2009	362	no (4L morning of)	age > 60 years old	2.8 (1.04–7.4)
			diabetes	8.6 (6.3–19.4)
			appendectomy	4.6 (2.0–10.5)
			colorectal resection	7.5 (3.4–17.6)
			hysterectomy	3.4 (1.1–10.4)
Lebwohl et al. 2010	12,430	no	on Medicaid	1.84 (1.61–2.11)
			later time of day appt	1.89 (1.71–2.09)
			marital status	0.89 (0.80–0.98)
			increased age	1.09 (1.05–1.14)
			male	1.44 (1.31–1.59)
			inpatient status	1.51 (1.26–1.80)

Author	N	Split Prep used?	Variable	OR (95% CI)
Ness et al. 2001	649	approximately half	Procedure time	1.15 (1.05, 1.25)
			non-adherence to prep instructions	2.68 (1.52, 4.75)
			cirrhosis	3.71 (1.17, 11.75)
			inpatient status	3.13 (1.15, 8.50)
			constipation	2.81 (1.10, 7.20)
			tricyclic antidepressant	2.99 (1.10, 8.15)
			hx of polyps	0.55 (0.31, 0.98)
			male	1.54 (1.03, 2.30)
			stroke or dementia	2.23 (1.00, 4.97)

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Table 4

Methods to improve patient compliance and adherence to bowel preparations (ref. 45,46).

Clear instructions	<ul style="list-style-type: none"> • Instructions in both verbal and written form • Effective for a wide range of health literacy and education levels • Education tools (booklets, visual aids, cell phone apps, etc.) that are standardized and valid
Instructions on product label for splitting the preparation	<ul style="list-style-type: none"> • Current product instructions do not generally include split preparation instructions, these would need to be added by the pharmacy to the product
Pre-procedure phone calls	<ul style="list-style-type: none"> • Clinic staff confirm that patient understands appointment date and diet instructions • Verify split-preparation instructions and emphasize completing the entire volume • Standardized templates are used for recording pre-calls in medical record • Phone number for patients to call if they have questions, including instructions to page the GI fellow on call if they have questions the night before the procedure.
Alternative Preparation available	<ul style="list-style-type: none"> • Availability of at least two alternative bowel preparation options. These would include a reduced volume preparation for patients who are unable to take a 4L preparation even if it is split (if no risk factors for renal disease), and an augmented regimen for patients that failed a previous preparation despite adequate compliance (e.g., two day low residue or clear liquid diet with 4 L PEG split prep with the addition of one bottle magnesium citrate the evening before; premedication with metochlopramide 20 mg to prevent nausea if no neurologic co-morbidity)

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