

Bowel preparation before colonoscopy

This is one of a series of documents discussing the use of GI endoscopy in common clinical situations. The Standards of Practice Committee of the American Society for Gastrointestinal Endoscopy prepared this document that updates a previously issued consensus statement and a technology status evaluation report on this topic.^{1,2} In preparing this guideline, a search of the medical literature was performed by using PubMed between January 1975 and March 2014 by using the search terms “colonoscopy,” “bowel preparation,” “intestines,” and “preparation.” Additional references were obtained from the bibliographies of the identified articles and from recommendations of expert consultants. When limited or no data exist from well-designed prospective trials, emphasis is given to results from large series and reports from recognized experts. Recommendations for appropriate use of endoscopy are based on a critical review of the available data and expert consensus at the time that the documents are drafted. Further controlled clinical studies may be needed to clarify aspects of recommendations contained in this document. This document may be revised as necessary to account for changes in technology, new data, or other aspects of clinical practice. The recommendations were based on reviewed studies and were graded on the strength of the supporting evidence (Table 1).³ The strength of individual recommendations is based both on the aggregate evidence quality and an assessment of the anticipated benefits and harms. Weaker recommendations are indicated by phrases such as “we suggest,” whereas stronger recommendations are typically stated as “we recommend.”

This guideline is intended to be an educational device to provide information that may assist endoscopists in providing care to patients. It is not a rule and should not be construed as establishing a legal standard of care or as encouraging, advocating, requiring, or discouraging any particular treatment. Clinical decisions in any particular case involve a complex analysis of the patient's condition and available courses of action. Therefore, clinical considerations may lead an endoscopist to take a course of action that varies from these recommendations and suggestions.

Colonoscopy is the current standard method for imaging the mucosa of the entire colon. Large-scale reviews have shown rates of incomplete colonoscopy, defined as the inability to achieve cecal intubation and mucosal visualization effectively,^{4,5} between 10% and 20%,⁴ well over targets recommended by the U.S. Multi-Society Task Force on Colorectal Cancer.⁶ The diagnostic accuracy and therapeutic safety of colonoscopy depends, in part, on the quality of the colonic cleansing or preparation.⁷ Inadequate bowel preparation can result in failed detection of prevalent neoplastic lesions and has been linked to an increased risk of procedural adverse events.^{1,8} Sidhu et al⁹ performed an audit of all colonoscopies performed between April 2005 and 2010 at the Royal Liverpool University. Of the 8910 colonoscopies performed, 693 were incomplete (7.8%; 58% women; mean age, 61 years), and inadequate bowel preparation was the most common reason for incomplete colonoscopy, accounting for nearly 25% of failed colonoscopies in their series.

Numerous investigations designed to identify predictors of inadequate colonoscopy bowel preparation⁶⁻⁸ have found that inadequate preparation is more common in patients with the following characteristics: previous inadequate bowel preparation, non-English speaking, Medicaid insurance, single and/or inpatient status, polypharmacy (especially with constipating medications such as opiates), obesity, advanced age, male sex, and comorbidities such as diabetes mellitus, stroke, dementia, and Parkinson's disease.^{1,10,11} Poor adherence to preparation instructions, erroneous timing of bowel purgative administration, and longer appointment wait times for colonoscopy have also been associated with poor bowel preparation.^{10,11} Thus, it is important for clinicians to understand the numerous modifiable physician- and patient-related factors that can lead to colonoscopy failure to reduce its incidence and provide patients with improved outcomes.

The ideal preparation for colonoscopy should reliably empty the colon of all fecal material in a rapid fashion with no gross or histologic alteration of the colonic mucosa. The preparation should not cause patient discomfort or shifts in fluids or electrolytes. The preparation should be safe, convenient, tolerable, and inexpensive.¹² Unfortunately, none of the currently available preparations have all of these characteristics. This document updates a previous consensus document and a technology status evaluation report on bowel preparation^{1,2} and reviews the available evidence regarding bowel preparation before colonoscopy.

TABLE 1. GRADE system for rating the quality of evidence for guidelines

Quality of evidence	Definition	Symbol
High quality	Further research is very unlikely to change our confidence in the estimate of effect	⊕⊕⊕⊕
Moderate quality	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate	⊕⊕⊕○
Low quality	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	⊕⊕○○
Very low quality	Any estimate of effect is very uncertain	⊕○○○

Adapted from Guyatt et al.³

GENERAL CONSIDERATIONS

It is important that patients are educated and engaged in the colonoscopy preparation process,¹³ and it has been shown that effective education significantly improves the quality of bowel preparation.¹⁴ Patient counseling along with written instructions that are simple and easy to follow and in their native language should be provided to patients,¹⁵ and patient education may improve with the use of visual aids.¹⁶ Recently, educational booklets were shown to improve bowel preparation and quality indicators such as cecal intubation rates.^{17,18} Smartphone applications have even been developed to guide patients through the preparation process.¹⁹ Patients can also be directed to resources such as the ASGE Website entitled “Understanding Bowel Preparation” (<http://www.asge.org/patients/patients.aspx?id=10094>) that explain the steps involved and importance of optimizing bowel preparation for colonoscopy.

Bowel preparation regimens typically incorporate dietary modifications along with oral cathartics.²⁰ Most commonly, a clear liquid diet is advised for the day before colonoscopy. Red liquids can be mistaken for blood in the colon or can obscure mucosal details and should be avoided. Clear liquids can be taken up to 2 hours before the procedure.²¹ However, it is not clear whether a clear liquid diet the day before colonoscopy offers advantages over a low-fiber diet in terms of preparation quality.²²⁻²⁵ A low-residue diet that avoids foods containing seeds and other indigestible substances is often recommended for several days before the procedure and has been shown to be at least as effective as a clear liquid diet^{20,26} and associated with increased patient satisfaction.²³

Although the individual components of bowel preparations vary widely, the combination of dietary restriction and cathartics has proven to be safe and effective for colonic cleansing for colonoscopy.²⁷ In a study of hospitalized patients undergoing colonoscopy, a clear liquid diet before administration of the bowel preparation was the

only dietary modification that improved the quality of preparation.²⁸ Adequate hydration is an important adjunct to any bowel preparation before colonoscopy.²⁹ Additional medication modifications may be required in special populations such as diabetic patients, who must maintain glycemic control, and patients taking anticoagulation agents.³⁰

TIMING OF PREPARATION

Giving part (usually half) of the bowel preparation dose on the same day as the colonoscopy (termed split-dose) results in a higher-quality colonoscopy examination compared with ingestion of the entire preparation on the day or evening before colonoscopy.³¹⁻³⁹ A higher-quality bowel preparation due to this split-dose has been demonstrated to increase the adenoma detection rate.⁴⁰ In addition to a higher-quality bowel preparation, split-dosing also improves patient tolerance, as demonstrated by an increased willingness to repeat the procedure using the same preparation in the future.³⁷ Typically, the standard dose of a bowel preparation is split between the day before and the morning of the procedure. The timing of the second dose must allow sufficient time for the patient to complete the second dose, have the desired response, and for the patient to travel to the center where the colonoscopy will be performed. The second dose should be administered between 3 to 8 hours before the planned start of the colonoscopy procedure.^{41,42} A prospective trial found no difference in residual gastric fluid in patients using split-dose bowel preparation and bowel preparation given the evening before colonoscopy.⁴³ Patients must have completed the preparation at least 2 hours before sedation is given to avoid potential aspiration as recommended in the American Society of Anesthesiologists (ASA) guidelines.²¹ However, institutional policies may vary from this ASA recommendation. In patients with early morning appointments, this second morning dose may be

inconvenient as it may require waking very early to take the second dose of bowel preparation. However, when educated on the advantages of split-dose bowel preparation on effectiveness of cleansing, the vast majority of potential patients express willingness to awaken at 2 to 3 AM to complete the regimen.⁴⁴ This approach has repeatedly been shown to result in an improved quality of colonic cleansing and is recommended for both morning and afternoon procedures. Hospitalized patients also prefer split-dosing, although no difference in quality of preparation was noted compared with a morning-only preparation.⁴⁵⁻⁴⁷

In patients undergoing colonoscopy in the afternoon, the bowel preparation may be administered entirely on the morning of the examination. One study of a 4-L bowel preparation in patients undergoing afternoon procedures demonstrated superior quality and tolerability when ingested the morning of the procedure compared with the evening before.⁴⁸ Other studies have also shown equivalent or improved bowel preparation quality with superior tolerability, less impact on activities of daily living, and better sleep quality when the bowel preparation is given only on the day of the procedure for afternoon colonoscopies.^{36,49,50}

REGIMENS FOR COLONIC CLEANSING BEFORE COLONOSCOPY

The currently available preparations commonly used for colonoscopy preparation are summarized in Table 2. For the purposes of this document, the classification of preparations as high-volume denotes that the preparation requires at least 4 L of cathartic consumption. Preparations described as low-volume preparations require smaller volumes of cathartic consumption, but the reader should understand that the recommended additional fluid intake with so-called low-volume preparations may approach 4 L total liquid volume for optimal preparation results.

Isosmotic agents

High-volume polyethylene glycol preparations.

Polyethylene glycol (PEG) is an inert polymer of ethylene oxide formulated as a nonabsorbable solution designed to pass through the bowel without net absorption or secretion. Isosmotic preparations that contain PEG are osmotically balanced with nonfermentable electrolyte solutions. Therefore, significant fluid and electrolyte shifts are theoretically minimized by the use of balanced electrolytes. The use of PEG-electrolyte solutions (PEG-ELS) is one of the most common methods of cleansing the colon. Large volumes (4 L) have traditionally been used to achieve a cathartic effect. Although 4-L PEG-ELS is not U.S. Food and Drug Administration (FDA) approved to be administered in a split-dose fashion (single-dosing is approved), there is abundant evidence that the highest-quality

preparations are achieved by using 4-L split-dose PEG-ELS regimens, and this is considered the current criterion standard colonoscopy preparation.⁵¹

Although PEG-ELS is generally well tolerated, 5% to 15% of patients do not complete the preparation because of poor palatability and/or large volume.⁵² In clinical trials, PEG-ELS does not result in significant physiologic changes as measured by patient weight, vital signs, serum electrolytes, blood chemistries, and complete blood counts.⁵³⁻⁵⁵ PEG-ELS does not alter the histologic features of the colonic mucosa and may be used in patients suspected of having inflammatory bowel disease without obscuring the diagnostic capabilities of colonoscopy or tissue sample analysis.⁵⁶ PEG-ELS is considered generally safe for patients with pre-existing electrolyte imbalances and for patients who cannot tolerate a significant sodium load (eg, those with renal failure, congestive heart failure, or advanced liver disease with ascites).⁵⁷

Multiple studies show that the routine addition of prokinetic agents or bisacodyl to 4-L PEG-ELS administration does not improve patient tolerance or colonic cleansing.^{54,58-60} The additional use of enemas does not offer any improvement in the efficacy of PEG-ELS, but does increase patient discomfort.⁶¹ PEG-ELS gut lavage via nasogastric (NG) tube is the most effective method for colonic cleansing in infants and children.⁶²⁻⁶⁴ In addition, the use of high-dose (6-8 L) PEG-ELS lavage via an NG tube is effective as a rapid bowel preparation in patients with acute lower GI bleeding.⁶⁵

A disadvantage of 4-L PEG-ELS is the relatively large volume of fluid consumption required, which can cause abdominal fullness and cramping. There is a sulfate-associated taste that is often perceived as unpleasant and is only partially masked by the addition of flavorings. Taking the solution after it is chilled may make it more palatable. These preparations work most effectively when ingested quickly (eg, 240 mL every 10 minutes). Adverse events in patients receiving PEG-ELS have been reported and include nausea with and without vomiting, abdominal pain, rare pulmonary aspiration, Mallory-Weiss tear, pancreatitis, colitis, lavage-induced pill malabsorption, cardiac arrhythmia, and exacerbation of inappropriate antidiuretic hormone secretion syndrome.⁶⁶⁻⁶⁸

Sulfate-free PEG-ELS. PEG-based lavage solution without sodium sulfate was developed to improve the smell and taste of PEG-ELS.⁵⁵ The improved taste was the result of a decrease in potassium concentration, increase in chloride concentration, and complete absence of sodium sulfate. The elimination of sodium sulfate results in a lower luminal sodium concentration. Therefore, the mechanism of action is dependent on the osmotic effects of sulfate-free (SF) PEG-ELS.⁶⁹ SF-PEG-ELS is less salty, more palatable, and comparable to PEG-ELS in terms of effective colonic cleansing, overall patient tolerance, and safety.⁷⁰

Low-volume PEG preparations. Low-volume PEG-ELS preparations were formulated to provide a more

TABLE 2. Commercially available bowel preparations*

	PEG-ELS	SF-PEG-ELS	Low-volume PEG-ELS with ascorbic acid	Low-volume PEG-3350-SD
Brand name	GoLYTELY	NuLYTELY; Trilyte	Moviprep	Miralax
Company (location)	Braintree Laboratories (Braintree, Mass)	Braintree Laboratories	Salix Pharmaceuticals (Raleigh, NC)	Merck (Boston, MA)
Composition	PEG, sodium sulfate, sodium bicarbonate, sodium chloride, potassium chloride	PEG, sodium bicarbonate, sodium chloride, potassium chloride	PEG-3350, sodium sulfate, sodium chloride, ascorbic acid	PEG-3350
Purgative volume/amount; recommended minimum additional fluid (per prescribing information for FDA-approved products)	4 L; none	4 L; none	2 L; 1 L clear liquid	238 g PEG-3350 in 2 L SD; regimens vary
FDA approval	Yes	Yes	Yes	No
Average wholesale price, US\$	24.56	26.89 (NuLYTELY) 27.98 (Trilyte)	81.17	10.08
Dosing regimens†	Split-dose: 2-3 L day before and 1-2 L day of procedure Single dose: 4L day before	Split-dose: 2-3 L day before and 1-2 L day of procedure Single dose: 4L day before	Split-dose: 1 L day before and 1 L day of procedure Single-dose: 2 L day before	Split-dose: 1 L day before and 1 L day of procedure Single dose: 2L day before
Specific comments	Criterion standard; least palatable preparation	More palatable than PEG-ELS	Avoid in patients with glucose-6-phosphate dehydrogenase deficiency	Not balanced ELS; unclear whether electrolyte shifts may occur

PEG-ELS, Polyethylene glycol electrolyte solution; SF, sulfate free; NaP, sodium phosphate; SD, sports drink; FDA, U.S. Food and Drug Administration; OSS, oral sodium sulfate.

*Split-dose recommended whenever possible.

†The authors suggest an additional 1 to 2 L of clear fluid intake beyond that recommended in prescribing information.

tolerable bowel preparation with a similar efficacy compared with the original 4-L PEG-ELS preparations. Low-volume 2-L PEG-ELS with ascorbic acid is the only FDA-approved low-volume PEG-ELS preparation commercially available at this time. Studies comparing this preparation with a 4-L PEG-ELS preparation or a sodium phosphate preparation showed similar efficacy.⁷¹⁻⁷⁷ This preparation should be used cautiously in patients with glucose-6-phosphate dehydrogenase deficiency as ascorbic acid may provoke hemolysis in these patients.⁷⁸

Hyposmotic agents

Another low-volume PEG preparation requires the addition of a commercially available electrolyte solution in the form of a sports drink to PEG-3350 (PEG-SD). It should

be emphasized that the combination of a sports drink and PEG-3350 is hypotonic, is not FDA approved for colonoscopy preparation, and is not equivalent to FDA-approved low-volume 2-L isosmotic PEG-ELS preparations. However, low-volume 2-L PEG-SD (using over-the-counter generic or name brand PEG-3350) is widely used and is often administered with adjuncts such as bisacodyl.⁷⁹ Studies that have compared full-volume 4-L PEG-ELS with low-volume 2-L PEG-SD combined with bisacodyl have demonstrated mixed results.⁸⁰ One study suggested that there may be a lower adenoma detection rate with the low-volume 2-L PEG-SD/bisacodyl preparation compared with a 4-L PEG-ELS preparation due to differences in bowel preparation quality.⁸¹ A 4-armed study compared 4-L PEG-ELS administered the evening before, split-dose 4-L

TABLE 2. Continued

Oral sodium sulfate	Oral sodium sulfate with PEG-ELS	Sodium picosulfate/magnesium oxide/anhydrous citric acid	Magnesium citrate	NaP tablets
Suprep	Suclear	Prepopik	Generic	Osmoprep
Braintree Laboratories	Braintree Laboratories	Ferring Pharmaceuticals Inc. (Parsippany, NJ)	Over the counter (OTC)	Salix Pharmaceuticals
Sodium sulfate, potassium sulfate, magnesium sulfate	Sodium sulfate, potassium sulfate, magnesium sulfate, PEG-3350	Sodium picosulfate, magnesium sulfate, anhydrous citric acid	Magnesium citrate	Monobasic and dibasic NaP
12 oz; 2.5 L water	6 oz OSS/2 L PEG-ELS; 1.25 L water	10 oz 2 L water	20-30 oz 2 L water	32 tablets 2 L water†
Yes	Yes	Yes	No	Yes
91.96	77.94	95.34	2.48	150.84
Split-dose: 6 oz OSS with 10 oz of water + 32 oz water day before and 6 oz OSS with 10 oz of water + 32 oz. water day of procedure	Split-dose: 6 oz OSS with 10 oz of water + 32 oz water day before and 2 L PEG-ELS day of procedure Single-dose: Evening before-6 oz. OSS with 10 oz of water + 16 oz water followed by 2 L PEG-ELS + 16 oz water 2 h after OSS	Split-dose: 5 oz Prepopik day before + 40 oz clear liquids and 5 oz Prepopik + 24 oz clear liquids day of procedure Single dose: 5 oz. + 40 oz. clear liquids the afternoon or early evening before the procedure and 5 oz + 24 oz clear liquids 6 h later	Split-dose: 1-1.5 10-oz bottles day before and 1-1.5 10 oz bottles day of procedure	Split-dose: 20 tablets day before and 12 tablets day of procedure
		Avoid in patients with renal insufficiency	Avoid in patients with renal insufficiency, elderly; not recommended for routine use	Avoid in patients with renal insufficiency or risk factors for acute phosphate nephropathy; not recommended for routine use

PEG-ELS, low-volume 2-L PEG-SD administered the evening before, and split-dose low-volume 2-L PEG-SD.⁸² This study found that both split-dose regimens were superior to the evening dose-only regimens with no significant preparation quality differences between the 4-L PEG-ELS and the PEG-SD preparations. Other studies comparing a 4-L PEG-ELS preparation with a low-volume 2-L PEG-SD preparation have found no differences in bowel preparation quality.^{83,84}

The safety of PEG-SD combined with bisacodyl has not been well reported to date. It remains unclear whether the addition of bisacodyl is beneficial and whether its use may increase side effects without improving the quality of the preparation.⁸⁵ Although there are theoretical concerns regarding mixing PEG-3350 with Crystal Light or Gatorade

due to the potential of unabsorbed carbohydrates to be metabolized into explosive gases, no such adverse events have been reported to date. There have been rare reports of hyponatremia.⁸⁶ In studies that evaluated the metabolic effects of the PEG-SD preparation compared with a standard PEG-ELS regimen, there were no clinically significant electrolyte changes from baseline due to the bowel preparation.^{82,84} However, a recent study compared the effects of PEG-SD (n = 180) with an FDA-approved low-volume 2-L PEG-ELS (n = 184) on serum electrolytes and found that changes from baseline in serum Na, K, and Cl were significantly greater with PEG-SD.⁸⁷ The incidence of hyponatremia, the primary endpoint of the study, with PEG-SD was nearly twice that with the low-volume 2-L PEG-ELS (3.9% vs 2.2%, odds ratio 1.82, 95% confidence interval,

0.45-8.62), although this difference was not statistically significantly different. Preparation completion and overall colonic cleansing (per the Aronchick Scale) were similar between the groups.

Hyperosmotic agents

Oral sodium sulfate. Oral sodium sulfate (OSS) preparations have not been associated with significant fluid and electrolyte shifts, likely because sulfate is a poorly absorbed anion. One study that compared this preparation with low-volume 2-L PEG-ELS with ascorbic acid found OSS to be noninferior.⁸⁸ In a multicenter study of 136 patients receiving OSS versus 4-L of SF-PEG-ELS, patients who ingested the OSS had less bloating, more successful preparation administration, and more frequent achievement of an excellent preparation (71.4% vs 34.3%, $P = .01$).⁸⁹ There are limited data available on the safety of OSS, although no serious adverse effects have been reported to date. In one report, patients receiving the entire OSS preparation in 1 day did report slightly increased GI events and higher vomiting scores compared with 4-L PEG-ELS; however, this was not seen in the split-dose regimen.⁸⁸

Rex et al⁹⁰ recently reported the results of a multicenter study that compared split-dose OSS with split-dose sodium picosulfate/magnesium citrate. Among 338 patients randomized to receive either preparation, OSS resulted in a higher rate of successful (excellent or good) preparation (94.7% vs 85.7%; $P = .006$) and more excellent preparations (54% vs 26%; $P < .001$) compared with sodium picosulfate/magnesium citrate. Both preparations were well tolerated, and there was no difference in treatment-emergent adverse events between the 2 preparations.

Magnesium citrate. Magnesium citrate is a saline solution laxative containing magnesium cations that acts osmotically and also stimulates the release of cholecystokinin, resulting in intraluminal accumulation of fluid and electrolytes promoting small intestinal and possibly colonic transit. Magnesium citrate is not FDA approved as a colonoscopy preparation, and there are limited data evaluating its effectiveness as a stand-alone colonoscopy preparation. One study that compared magnesium citrate with an aqueous sodium phosphate preparation found the magnesium citrate preparation to be superior.⁹¹ Magnesium is excreted via the kidneys, and this preparation should be avoided in patients with known kidney disease or the elderly. Magnesium toxicity can result in bradycardia, hypotension, nausea, and drowsiness. Serious adverse events including death have been reported.^{92,93} Because of the limited efficacy data and potential toxicity associated with this preparation, it is not recommended for routine colonoscopy preparation.

Sodium phosphate. Aqueous sodium phosphate is a low-volume hyperosmotic solution that, due to serious adverse events, is no longer recommended, and the brand name version was voluntarily withdrawn from the market

(although other brands are still available over the counter as laxatives). Patients with compromised renal function, dehydration, hypercalcemia, or hypertension treated with angiotensin-converting enzyme inhibitors or angiotensin receptor blockers have experienced phosphate nephropathy after use of oral sodium phosphate solutions.⁹⁴ The effects seem to be primarily age and dose related, although phosphate nephropathy after sodium phosphate ingestion has been reported to occur in patients without underlying disease.⁹⁵ Although usually asymptomatic, hyperphosphatemia is seen in as many as 40% of healthy patients completing sodium phosphate preparation and is especially significant in patients with renal failure.^{63,96} In addition, sodium phosphate has been shown to cause elevated blood urea nitrogen levels, increased plasma osmolality, hypocalcemia,^{97,98} hyponatremia, and seizures.⁹⁹ Sodium phosphate can cause clinically important fluid and electrolyte shifts, especially in elderly patients or patients with bowel obstruction, small intestinal disorders, impaired gut motility, renal or liver disease, or congestive heart failure.¹⁰⁰ Because of the risk of renal injury and electrolyte abnormalities, the FDA has issued a box warning for the prescription tablet form of sodium phosphate.¹⁰¹

Combination agents

Sodium picosulfate/magnesium citrate. Sodium picosulfate/magnesium citrate preparations have recently become available in the United States. This preparation acts locally in the colon as a combination of a stimulant laxative to increase the frequency and force of peristalsis (sodium picosulfate component) and an osmotic laxative to retain fluid in the colon (magnesium citrate component).¹⁰² Sodium picosulfate is a prodrug that is hydrolyzed by bacteria in the colon to its active metabolite 4,4'-dihydroxy-diphenyl-(2-pyridyl) methane. Two phase 3 clinical trials were conducted in the United States before FDA approval of this preparation.^{103,104} One of these trials compared a split-dose sodium picosulfate/magnesium citrate regimen with a day-before low-volume 2-L PEG-ELS with 10 mg bisacodyl regimen and found improved bowel cleansing and patient acceptance with sodium picosulfate/magnesium citrate.¹⁰³ It should be noted, however, that the split-dose regimen likely favored the sodium picosulfate/magnesium citrate arm, constipated patients were excluded from the trial, and the rate of adequate preparation observed with sodium picosulfate/magnesium citrate was only 84.2%. The other phase 3 trial compared sodium picosulfate/magnesium citrate with low-volume 2-L PEG-ELS with 10 mg bisacodyl, both administered the day before the colonoscopy and found sodium picosulfate/magnesium citrate to be noninferior to PEG-ELS with 10 mg bisacodyl.¹⁰⁴ In this trial, sodium picosulfate/magnesium citrate resulted in adequate cleansing in only 83%.

Adverse events associated with this preparation are generally GI in nature and mild to moderate in severity.

Subjects receiving the entire preparation in 1 day reported increased abdominal cramps/pain and higher nausea/vomiting scores; however, these symptoms were better tolerated in a split-dose regimen. There are rare reports of hyponatremia and other electrolyte disturbances that have caused significant clinical symptoms with this preparation.^{102,105}

Sodium sulfate and SF-PEG-ELS. Recently, a preparation consisting of a combination of OSS with 2 L of SF-PEG-ELS has become commercially available. The results of two randomized, controlled trials involving 737 outpatients undergoing colonoscopy with this preparation compared with 2 other low-volume PEG-ELS preparations were recently reported.¹⁰⁶ In the first trial, 186 patients received OSS+SF-PEG-ELS, and 185 patients received a low-volume 2-L PEG-ELS with ascorbic acid preparation, both administered in a split-dose fashion. Both preparations resulted in successful (excellent or good) bowel preparation scores in 93.5%. In this trial, OSS+SF-PEG-ELS was associated with twice the rate of vomiting compared with the PEG-ELS with ascorbic acid (13.5% vs 6.7%, $P = .042$). In the second trial, OSS+SF-PEG-ELS ($n = 196$) was compared with PEG-ELS + 10 mg bisacodyl, both administered the evening before the colonoscopy. OSS+SF-PEG-ELS resulted in successful preparation in 89.8% of patients compared with 83.5% with PEG-ELS + bisacodyl ($P < .001$ for noninferiority). In this trial, overall discomfort was rated worse with OSS+SF-PEG-ELS (mean score, 2.1 vs 1.8; $P = .032$). There were no serious adverse events considered related to the preparations in either trial.

ADJUNCTIVE MEASURES

Laxatives

Laxatives such as bisacodyl and/or magnesium citrate are administered in some regimens to reduce the volume of lavage solution required and hence volume-related symptoms, such as abdominal bloating and cramping. Bisacodyl is a diphenylmethane derivative that is poorly absorbed in the small intestine and is hydrolyzed by endogenous esterases. Its active metabolites stimulate colonic peristalsis.¹⁰⁷ One study of bisacodyl as a preparation adjunct found that the laxative shortened the duration of whole-gut irrigation, although no significant difference in colonic cleansing was identified.¹⁰⁸ When used as an adjunct to PEG-ELS, bisacodyl did allow for less volume of PEG-ELS required for adequate colonic cleansing.^{109,110} Bisacodyl can cause abdominal cramping and has been associated with ischemic colitis.¹¹¹ Accordingly, when used as an adjunctive agent for bowel preparations, 5- and 10-mg doses are recommended. The only FDA-approved regimen of low-volume 2-L PEG-ELS combined with bisacodyl was discontinued by the manufacturer in 2013.

Two studies found that magnesium citrate used as an adjunct to PEG-ELS allowed less PEG-ELS solution (2 L)

to be used to achieve adequate cleansing.^{109,112} The use of magnesium citrate as an adjunct to other colonic preparations may also be helpful in patients who have previously had inadequate preparation by using a standard bowel preparation or those with a long-standing history of constipation. Studies of full-volume (4 L) PEG-ELS compared with low-volume (2 L) SF-PEG-ELS combined with magnesium citrate or bisacodyl demonstrate equal efficacy of colonic cleansing, with improved overall patient tolerance.^{34,113} Because of the renal excretion of magnesium, magnesium citrate should be avoided in patients with renal insufficiency or renal failure.

Senna is a stimulant laxative that contains anthraquinone derivatives (glycosides and sennosides) that are activated by colonic bacteria. The activated derivatives have a direct effect on intestinal mucosa, increasing the rate of colonic motility, enhancing colonic transit, and inhibiting water and electrolyte secretion.¹¹⁴ Senna has been used as an adjunct to PEG-ELS regimens in a manner similar to that of bisacodyl.¹¹⁵ No differences were found between senna and bisacodyl when used as an adjunct in combination with PEG-ELS.³⁴ The adjunctive use of senna with PEG-ELS solutions has been demonstrated to improve the quality of bowel preparation¹¹⁶ and to reduce the amount of PEG-ELS required for effective bowel preparation.¹¹⁷

Flavoring

There have been many attempts to improve the flavor of PEG-ELS. As a result, PEG-ELS is available in multiple flavors. Gatorade, Crystal Light, and carbohydrate-electrolyte solutions have been used to improve palatability in nonelectrolyte balanced PEG solutions; however, improved flavor does not necessarily equate to improved tolerance.¹¹⁸ Care must be taken to avoid adding substrates to the preparation that can metabolize into explosive gases^{119,120} or significantly alter water and electrolyte absorption. One study suggested that sugar-free menthol candy drops may improve palatability and tolerability of a split-dose PEG-ELS preparation.¹²¹

Nasogastric tube administration of colonic preparations

NG tubes have been used to instill colonic preparations, primarily PEG-ELS solutions, in both children and adults. The use of NG tubes to prepare a patient for colonoscopy may be required in patients unable to drink fluids or with a significant swallowing disorder. Purge preparations (rapid and high-volume) for patients with lower GI bleeding and urgent colonoscopy may require the placement and use of a NG tube. In addition to the potential adverse events related to placement of the NG tube, case reports have demonstrated the potential for severe, life-threatening adverse events, such as aspiration.⁵⁷ Adjunctive use of prokinetic and antiemetic agents as well as avoidance of overrapid installation of bowel preparation may make this route of administration more tolerable.

Metoclopramide

Metoclopramide is a dopamine antagonist gastroprokinetic that increases the amplitude of gastric contraction and increases peristalsis of the duodenum and jejunum, but does not change colonic motility. In one study, metoclopramide (5-10 mg orally) used as an adjunct to PEG-ELS reduced nausea and bloating, but did not improve colonic cleansing.⁵⁹ However, a second study revealed no advantage with either patient tolerance or colonic cleansing.⁶⁰ Metoclopramide is not recommended as an adjunct to oral bowel preparation.

Simethicone

Simethicone promotes the clearance of excessive gas in the GI tract that reduces bloating, abdominal discomfort, and abdominal pain and improves visualization in the GI tract. There have been several studies investigating the addition of simethicone to bowel preparation regimens.¹²² Overall, simethicone does not significantly change the quality of the bowel preparation; however, it does reduce the number of adherent bubbles present, which may enhance colonic visualization.

DOCUMENTATION OF PREPARATION QUALITY

It is important for preparation quality to be properly documented in colonoscopy reports. The U.S. Multi-Society Task Force on Colorectal Cancer defines an adequate examination as one that allows confidence that lesions other than small (≤ 5 mm) polyps were generally not obscured by residual colonic contents.¹²³ In clinical practice, preparation quality should be graded after efforts to remove residual effluent and fecal debris have been completed. Validated scoring systems that have been devised to rate the quality of colonoscopy preparation in clinical trials include the Aronchick Scale, the Ottawa Bowel Preparation Scale, and the Boston Bowel Prep Score (Table 3).^{124,125} The Aronchik Scale is a global rating best suited for comparing different bowel preparations because it assesses the quality of the preparation encountered during the initial inspection of the colon. The Ottawa Bowel Preparation Scale uses 3 colonic segment scores that are rated 0 to 4 and summed as part of a total score. The score has been validated comparison with the Aronchik Scale.¹²⁴ The Boston Bowel Preparation Score uses a 10-point score (0-9) summation score assessing bowel preparation quality in 3 segments of the colon after all cleansing maneuvers during colonoscopy and has been found to be both valid and reliable.¹²⁶

SPECIAL CONSIDERATIONS

Inadequate bowel preparation

Inadequate bowel preparation for colonoscopy can result in missed lesions, canceled procedures, increased procedural time, increased costs, and a potential increase

in adverse event rates.^{127,128} In patients with fair bowel preparations, 28% to 42% had adenomas found when the examination was repeated within 3 years, including up to 27% with advanced adenomas.¹²⁸⁻¹³⁰ It has been estimated that intraprocedural cleansing accounts for 17% of total colonoscopy procedural time.¹³¹ One study that examined possible causes of poor preparation found that less than 20% of patients with an inadequate colonic preparation reported a failure to adequately follow preparation instructions.¹³² The most important predictor of inadequate preparation is a previous inadequate preparation. Other independent factors that have been shown to predict inadequate colon preparation include later colonoscopy starting time, failure to follow preparation instructions, hospitalized patients, procedural indication of constipation, use of tricyclic antidepressants, male sex, and a history of cirrhosis, stroke, or dementia. Obesity may also be a predictor of a poor bowel preparation.^{133,134}

Consideration should be given to prescribing more aggressive preparations in patients who have a history of inadequate preparation quality or medical predictors of inadequate preparation. Patients who have factors predicting a lower likelihood of following preparation instructions (such as those who are non-English speaking or cognitively impaired) should receive intensified education and/or be assigned to a dedicated patient navigator. Before the examination and administration of sedation, patients should be queried about their compliance with the preparation and the quality of their effluent. Patients with persistent brown effluent should be considered for large-volume enemas or additional oral preparation before proceeding with colonoscopy.¹³⁵

Patients with an inadequate colon preparation usually require a repeat examination with a more thorough attempt at colonic cleansing.¹³⁶ There is no standardized approach to an inadequately prepared colon discovered on intubation. Several irrigation devices have been developed to permit more aggressive water instillation than can be achieved with standard irrigation pumps or syringe-based flushing.^{137,138} Anecdotal approaches to managing inadequate preparation during colonoscopy include instilling an enema through the colonoscope and reattempting the procedure after the patient has evacuated the enema or allowing the patient to drink additional oral preparation and then reattempting the procedure.¹³⁹ Both of these approaches necessitate recovery from sedation and resedation and may be affected by institutional or logistical constraints.

In practice, there are highly variable recommendations regarding timing of follow-up colonoscopy when the bowel preparation is judged to be inadequate.¹⁴⁰ A recent study suggested that when patients were instructed to repeat colonoscopy the following day, nearly half (47%) complied, whereas rates for repeat colonoscopy were significantly lower among patients instructed to follow up at a later interval.¹⁴¹ In one study, the adenoma and advanced

TABLE 3. Bowel preparation scales

Bowel prep name	Points	Description
Aronchick Scale*	5	Inadequate (repeat preparation needed)
	4	Poor (semisolid stool could not be suctioned and <90% of mucosa seen)
	3	Fair (semisolid 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)
Ottawa Bowel Prep Scale rating for each colon segment‡	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)
Ottawa Bowel Preparation Scale rating for the amount of fluid in the whole colon‡	2	Large amount of fluid
	1	Moderate amount of fluid
	0	Small amount of fluid
Boston Bowel Preparation Scale rating for each colon segment‡	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

*Aronchick Scale rating for the whole colon (individual segments not evaluated).

‡Ottawa Bowel Preparation Scale total score is calculated by adding the scores of the right, transverse/descending, and sigmoid/rectum colon segments and the score for the fluid in the whole colon. The total Ottawa Bowel Preparation Scale score ranges from 14 (very poor) to 0 (excellent).

‡Boston Bowel Preparation Scale total score is calculated by adding the scores of the right, transverse, and left colon segments. The total Boston Bowel Preparation Scale score ranges from 0 (very poor) to 9 (excellent).

adenoma miss rates were 35% and 36%, respectively, for colonoscopies repeated in less than 1 year.¹²⁹ Although immediate repeat colonoscopy after additional or more aggressive preparation administration is the preferred approach in most patients, patients with inadequate bowel preparations should be offered repeat colonoscopy examinations at least within 1 year of the inadequate examination. A shorter interval is indicated when advanced neoplasia is discovered in an inadequately prepared colon.

Pediatric population

Although there are no national standards for pediatric bowel preparations for colonoscopy, review of the literature documents several commonly used preparations.¹⁴² This topic was reviewed in a previous guideline.¹⁴³

RECOMMENDATIONS

1. We recommend that bowel preparations be individualized by the prescribing provider for each patient based on efficacy, cost, safety, and tolerability considerations balanced with the patient's overall health, comorbid conditions, and preferences. ⊕⊕⊕⊕
2. We recommend that verbal counseling regarding preparation administration be provided to patients along with written instructions that are simple and easy to follow and in their native language. ⊕⊕⊕⊕
3. We suggest intensive education and more aggressive than standard bowel preparation regimens be considered for patients with predictors for inadequate preparation. ⊕⊕○○

4. We recommend a low-residue diet be used in conjunction with FDA-approved purgatives for bowel preparation before colonoscopy. ⊕⊕⊕○
5. We recommend split-dose regimens for all patients and/or same day preparations for afternoon colonoscopies with a portion of the preparation taken within 3 to 8 hours of the procedure to enhance colonic cleansing and patient tolerance. ⊕⊕⊕○
6. We recommend that sodium phosphate and magnesium citrate preparations not be used in the elderly or patients with renal disease or taking medications that alter renal blood flow or electrolyte excretion. ⊕⊕⊕⊕
7. We recommend against the use of metoclopramide as an adjunct to oral bowel preparation. ⊕⊕⊕○
8. We recommend that endoscopists document the quality of the bowel preparation at the time of colonoscopy with regard to adequacy. ⊕⊕⊕⊕
9. We recommend that patients with inadequate preparation be offered a repeat colonoscopy within 1 year. ⊕⊕⊕○

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Abbreviations: FDA, U.S. Food and Drug Administration; NG, nasogastric; OSS, oral sodium sulfate; PEG, polyethylene glycol; PEG-ELS, polyethylene glycol with electrolyte solutions; PEG-SD, polyethylene glycol with a sports drink; SF, sulfate free.

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