Colonoscopy preparation

The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methods are used with a MEDLINE literature search to identify pertinent clinical studies on the topic and a MAUDE (Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported complications of a given technology. Both searches were supplemented by accessing the “related articles” feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but, in many cases, data from randomized controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and Web-based publications, proprietary publications, and informal communications with pertinent vendors.

Technology Status Evaluation Reports are drafted by 1 or 2 members of the ASGE Technology Committee, reviewed and edited by the committee as a whole, and approved by the governing board of the ASGE. When financial guidance is indicated, the most recent coding data and list prices at the time of publication are provided. For this review, the MEDLINE database was searched through September 2008 for articles and references related to colonoscopy preparation by using the key words “preparation,” “randomized clinical trial,” “colonics cleansing,” “lavage,” “pediatric,” and “colonoscopy.” Practitioners should continue to monitor the medical literature for subsequent data about the efficacy, safety, and socioeconomic aspects of these preparations.

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BACKGROUND

Colonoscopy and other methods of colonic imaging require thorough large-bowel cleansing for safe and effective completion of the procedure. For colonoscopy, inadequate preparation is responsible for up to a third of all incomplete procedures and precludes up to 10% of examinations. This outcome negatively impacts the rate of polyp and adenoma detection. The ideal colon preparation would rapidly and reliably clean the colon of fecal material while having no effect on the gross or microscopic appearance of the colon. It would require a short period for ingestion and evacuation, cause no discomfort, and produce no significant fluid or electrolyte shifts. At the same time, it would be palatable, simple, and inexpensive. Currently, the available preparation regimens fulfill some but not all of these criteria.

TECHNOLOGY UNDER REVIEW

In general, compounds used for bowel cleansing can be divided into 3 categories according to their mechanism of action: isosmotic, hyperosmotic, and stimulant preparations. Their distinct physiologic mechanisms impact the choice of preparation, especially in patients with comorbidities, elderly patients, and children. Early regimens evolved from preparations for radiologic tests and included diet restrictions for 2 to 3 days, enemas, laxatives, and large-volume (7-12 L) oral bowel lavage. These regimens were time consuming, uncomfortable, and inconvenient for the patient, and resulted in fluid and electrolyte disturbances. In addition, early preparations contained mannitol, which, when fermented by colonic bacteria, led to combustible amounts of luminal methane and hydrogen and created a risk for intracolonic gas explosion when using electrocautery. This led to the development of osmotically balanced solutions formulated to provide minimal water absorption or secretion into the bowel lumen. A polyethylene glycol (PEG) electrolyte lavage solution (PEG-ELS) was originally developed in 1980, and, since then, several preparations have been introduced to improve palatability and compliance (sulfate-free PEG). Some more recent preparations allow for a reduced volume that needs to be ingested (PEG, also called PEG-3350 based on its molecular weight, combined with bisacodyl delayed release or magnesium citrate). Presently, the most commonly used adult colonoscopy preparations in the United States are PEG and oral sodium phosphate (NaP) regimens.
Isosmotic preparations

Isosmotic preparations that contain PEG are osmotically balanced, high-volume, nonabsorbable, and nonfermentable electrolyte solutions (Table 1). These solutions cleanse the bowel with minimal water and electrolyte shifts and provide evacuation, primarily by the mechanical effect of large-volume lavage. With sodium sulfate preparations, sodium absorption in the small intestine is largely reduced because of the absence of chloride, the accompanying anion necessary for active absorption against electrochemical gradient. The conventional total adult dose is 4 L, given orally as 240 mL every 10 minutes until rectal effluent is clear, or it is administered by a nasogastric (NG) tube at a rate of 20 to 30 mL/min. Alternatively, split dosing has also been advocated, with a portion taken the evening before and the residual taken the morning of the procedure. Low-volume PEG preparations are used in combination with stimulant laxatives or ascorbic acid. For one of these regimens, 10 mg of bisacodyl is included in the first bowel movement by 240 mL of preparation every 10 minutes until effluent is clear or until a total of 2 L is ingested. In another regimen, the ascorbic acid is included in the 2-L PEG solution, which is also dosed at 240 mL every 10 minutes. For this latter regimen, it is recommended that the patient ingest at least an additional 1 L of fluid, which makes the total volume of ingestion 3 L. Another formulation of PEG-3350, which does not contain electrolytes, has been approved and marketed as an agent to treat constipation (Table 1). This formulation has been used for colonic cleansing. However, these PEG agents without electrolytes are not approved for bowel preparation, and the volume required and safety for use as a bowel preparation has not been adequately defined.

Hyperosmotic preparations

Hyperosmotic preparations draw water into the bowel lumen, which stimulates peristalsis and evacuation. These are small-volume preparations but, because of their hyperosmotic nature, can cause fluid shifts, accompanied by transient electrolyte-level alterations. Oral NaP is available as an aqueous solution and a tablet form. An aqueous NaP preparation contains monobasic and dibasic NaP. It has a mean onset of bowel activity in 1.7 hours with the first dose and 0.7 hours with the second dose, a mean duration of activity of 4.6 and 2.9 hours, respectively, and end of bowel activity within 4 to 5 hours. Each 45-mL dose contains 29.7 g NaP. Two doses of 30 to 45 mL aqueous solution are given at least 10 to 12 hours apart, with the second dose given within 5 hours of the procedure. The tablet preparations contain 1.5 g NaP and 0.5 g of inactive ingredients. One of the inactive tablet ingredients, microcrystalline cellulose (MCC), was thought to reduce visibility at colonoscopy, and a new MCC-free preparation is now available. The dose is 40 tablets (60 g) for the MCC-containing preparation and 32 tablets (48 g) for the MCC-free preparation, both divided into 2 doses separated by 10 to 12 hours. All NaP regimens should be taken with a minimum of 2 L of clear liquids.

Sodium picosulfate acts similarly to NaP, producing a cathartic effect by osmotic action in the bowel. This preparation is commonly used outside of the United States and in combination with magnesium citrate. Magnesium citrate is a hyperosmotic agent, with additional effects through release of cholecystokinin, and results in fluid secretion and stimulation of peristalsis. Magnesium citrate has been used in combination with other agents but, as a sole agent, has typically been less effective. A magnesium citrate–based preparation that includes a 240-mL dose of balanced magnesium solution and 20 mg bisacodyl (oral) the evening before the procedure and a 10-mg bisacodyl suppository the morning of the procedure has been developed. As a means to improving the limited preparation achieved with magnesium citrate alone, another method involves adding pulsed rectal irrigation; however, this requires skilled nursing for administration and is associated with a high cost.

Stimulant preparations

Senna, an anthracene derivative, is processed by colonic bacteria, and its active ingredients, anthraquinones and their glucosides, stimulate colonic peristalsis. A bowel response can be expected approximately 6 hours after the dose ingestion. It has been used as the primary cleansing agent, with a liquid diet, particularly in children.

Adjunctive agents

Bisacodyl is a diphenylmethane derivative that is poorly absorbed in the small intestine and that is hydrolyzed by endogenous esterases. Its active metabolites stimulate colonic motility, with an onset of action between 6 and 10 hours. Metoclopramide is a dopamine receptor antagonist that sensitizes tissue to acetylcholine, which results in improved gastric contraction and small-bowel peristalsis. It has a half-life of 5 to 6 hours. Various dietary regimens, hydration electrolyte solutions, enemas, and antigastric agents are also used as adjuncts for colonoscopy preparation.

EASE OF USE

The main impediments to successful colon preparation are preparation volume and taste. Isotonic PEG preparations are better tolerated and favored by 90% of patients who previously tried older cleansing methods used before the availability of PEG regimens. The preparations still require ingestion of 2 to 4 L of fluid, which is a volume difficult to tolerate for some adults and for the majority of children, who often require NG tube administration. When comparing 2-L to 4-L PEG preparations, patients...
prefer the smaller-volume regimen.\textsuperscript{1} Because of the salty taste and smell of PEG-ELS, sulfate-free PEG preparations were developed\textsuperscript{13}; however, studies have not shown a clear tolerability advantage.\textsuperscript{1} To improve taste, flavored preparations, as well as flavoring packages, can be used. Flavoring packages may increase the osmotic load, and some contain carbohydrates that, with bacterial fermentation, may lead to production of combustible gases.\textsuperscript{30} Aqueous NaP preparations are of small volume but require dilution and, because of their salty taste, present difficulties to some patients. A tablet NaP preparation was developed to improve taste and tolerance, although tolerability comparison results are conflicting.\textsuperscript{31,32} Split-dose regimens may improve preparation efficacy but could add to patient inconvenience because of the need to take the second dose very early in the morning on the day of the procedure.

In a systematic review of 82 studies on colonoscopy preparation, statistical pooling of tolerability data was not possible because of inconsistent data collection, although it was reported that NaP was superior to PEG in a majority of studies.\textsuperscript{1} An earlier meta-analysis reported rates of failure to complete the preparation between 0% and 12% for NaP and 3% and 32% for PEG.\textsuperscript{33} A recent meta-analysis reviewed randomized controlled trials from 1990 to 2005 and compared the tolerability, efficacy, and safety of various preparations.\textsuperscript{34} Pooled data from 15 trials with 3293 patients that compared PEG and NaP preparations showed that 94.4% of patients completed taking NaP compared with 70.9% of patients taking PEG solution. The only 2 randomized pediatric trials that compared PEG with NaP involved a total of 63 children. In one study, NaP was better tolerated, but PEG was administered via an NG tube.\textsuperscript{35} In the other study, 53% of the patients in the PEG group could not complete oral administration, whereas only 7% of patients required NG-tube placement for completion of the NaP regimen. Patients who received NaP found it to be more tolerable than PEG ($P < .02$).\textsuperscript{36}

In 2 small studies, use of adjunctive agents metoclopramide and simethicone was shown to improve tolerability of PEG preparation,\textsuperscript{37,38} whereas the addition of bisacodyl and magnesium citrate\textsuperscript{14} or of senna\textsuperscript{33} decreased the amount of preparation necessary for effective cleansing. The PEG preparation with ascorbic acid was shown to be better tolerated than NaP\textsuperscript{19} and a full-volume PEG preparation.\textsuperscript{18} Carbohydrate-electrolyte solutions were used with aqueous NaP to improve palatability and hydration.\textsuperscript{39}

**OUTCOMES DATA AND COMPARATIVE STUDIES**

There is significant heterogeneity among colonoscopy preparation studies, which makes comparisons difficult. Overall, the best studied and most commonly used preparations, PEG and NaP, provide satisfactory colon cleansing in a majority of patients. A systematic review of these 2 regimens shows similar adequate preparation rates, 75% for NaP and 71% for PEG.\textsuperscript{1}

PEG-ELS preparations are more effective than traditional cleaning preparations, including dietary restrictions, laxatives, mannitol, and large-volume bowel lavage.\textsuperscript{28} Efficacy of the standard 4-L preparation can be improved by administration of split doses,\textsuperscript{17,40} even with minimal dietary restriction before the first dose.\textsuperscript{10} Ingestion of the entire preparation on the day of the procedure about 5 hours before the colonoscopy improved the clean-out quality when compared with patients who received PEG-ELS the previous day, approximately 19 hours before the procedure.\textsuperscript{41} Sulfate-free PEG preparations appear to be equally as effective as regular PEG-ELS.\textsuperscript{10} Adjunctive therapies, such as bisacodyl, metoclopramide, and enemas, do not seem to improve the efficacy of full-volume PEG preparations, although the addition of simethicone improves colon visibility.\textsuperscript{42} Low-volume PEG preparations combined with a stimulant agent showed similar efficacy to full-volume PEG preparations.\textsuperscript{14,43} In a multicenter trial, a 2-L sulfate-free PEG preparation with a 10-mg bisacodyl dose was as effective as the same preparation with the initially marketed 20-mg dose bisacodyl regimen.\textsuperscript{44} Most recently, a low-volume PEG preparation with ascorbic acid showed similar efficacy when compared with full-volume PEG\textsuperscript{18} and NaP\textsuperscript{19} preparations. In most randomized controlled trials, NaP preparations are reported to be equally or more effective compared with PEG preparations.\textsuperscript{22,23,45-65} The NaP tablets appear to be equally as effective as an aqueous NaP solution\textsuperscript{1} and a PEG preparation.\textsuperscript{22} A split-dose NaP schedule, with one dose taken the day before and one on the day of the procedure separated by 12 hours, was superior relative to a single dose.\textsuperscript{66,67}

In pediatrics, there is a lack of randomized controlled trials, and a wide variety of preparations are used.\textsuperscript{68} PEG solutions were used in 2 small randomized trials. Two studies compared PEG with NaP; one showed similar success rates (75% vs 71% for PEG and NaP, respectively),\textsuperscript{35} and one showed that NaP was superior (40% vs 95%).\textsuperscript{36} A third study found that PEG was superior to magnesium citrate with senna, and bisacodyl with an enema.\textsuperscript{69} PEG-3350 without electrolytes was shown to be efficacious in more than 90% of pediatric patients when used over a 4-day period.\textsuperscript{20} An NaP solution was found to be less effective when compared with magnesium citrate used with a low-residue diet in one study,\textsuperscript{70} although equally effective and more acceptable when compared with the same medication in addition to an enema.\textsuperscript{71} Various other regimens, including senna or magnesium citrate with enema\textsuperscript{27} and bisacodyl with enema,\textsuperscript{72,73} were found to be efficacious in open-label prospective trials.

In elderly patients, 2 studies with a total of 188 subjects 75 years old and older compared PEG with NaP and found them to be equally effective.\textsuperscript{51,88}
### TABLE 1. Agents used for bowel preparation

<table>
<thead>
<tr>
<th>Product (manufacturer)</th>
<th>Active agent</th>
<th>FDA approved for bowel preparation</th>
<th>Average wholesale price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Isosmotic</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Full volume</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colyte (SchwarzPharm, Mequon, Wis)</td>
<td>PEG</td>
<td>No Yes</td>
<td>4000 mL</td>
</tr>
<tr>
<td>Flavored</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonflavored</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GoLYTELY (Braintree, Braintree, Mass)</td>
<td>PEG (sulfate free)</td>
<td>&gt; 6 mo Yes</td>
<td>4000 mL</td>
</tr>
<tr>
<td>Flavored</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonflavored</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NuLYTELY (Braintree)</td>
<td>PEG (sulfate free)</td>
<td>&gt; 6 mo Yes</td>
<td>4000 mL</td>
</tr>
<tr>
<td>Flavored</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonflavored</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TriLyte (SchwarzPharm)</td>
<td>PEG (sulfate free)</td>
<td>&gt; 6 mo Yes</td>
<td>4000 mL</td>
</tr>
<tr>
<td>Flavored</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halfflytely (Braintree)</td>
<td>PEG and bisacodyl</td>
<td>No Yes</td>
<td>2000 mL</td>
</tr>
<tr>
<td>MoviPrep (Salix Pharmaceuticals, Inc, Morrisville, NC)</td>
<td>PEG and ascorbic acid</td>
<td>No Yes</td>
<td>2000 mL</td>
</tr>
<tr>
<td>Not approved for bowel preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MiraLax (Braintree)</td>
<td>PEG-3350 no electrolytes</td>
<td>No No</td>
<td>255 g</td>
</tr>
<tr>
<td>GlycoLax (Kremers Urban Co, Wilmington, Del)</td>
<td>PEG-3350 no electrolytes</td>
<td>No No</td>
<td>255 g</td>
</tr>
<tr>
<td><strong>Hyperosmotic</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fleet Phospho-Soda EZ-Prep (C.B. Fleet Co, Lynchburg, Va)</td>
<td>NaP (oral)</td>
<td>No</td>
<td>75 mL (30 &amp; 45)</td>
</tr>
<tr>
<td>Visicol (tablet, NaP; Salix Pharm)</td>
<td>NaP (oral)</td>
<td>No Yes</td>
<td>40 Tablets</td>
</tr>
<tr>
<td>Osmoprep, (MCC-free tablet; Salix Pharm)</td>
<td>NaP (oral)</td>
<td>No Yes</td>
<td>32 Tablets</td>
</tr>
<tr>
<td>Fleet, enema children (C.B. Fleet)</td>
<td>NaP enema</td>
<td>&gt; 2 y No</td>
<td>67.5 mL</td>
</tr>
<tr>
<td>Fleet Enema (C.B. Fleet)</td>
<td>NaP enema</td>
<td>&gt; 12 y Yes</td>
<td>135 mL</td>
</tr>
<tr>
<td>LoSoPrep Kit (E-Z-EM Inc, Lake Success, NY)</td>
<td>Magnesium citrate plus Bisacodyl oral and suppository</td>
<td>No Yes</td>
<td>1 Package</td>
</tr>
<tr>
<td>Magnesium Citrate (AmerisourceBergen, Chesterbrook, Pa)</td>
<td>Magnesium citrate</td>
<td>&gt; 6 y Yes</td>
<td>300 mL</td>
</tr>
<tr>
<td><strong>Adjunctive agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet Bisacodyl Enema 10 mg (C.B. Fleet)</td>
<td>Bisacodyl topical</td>
<td>No Yes</td>
<td>37.5 mL</td>
</tr>
</tbody>
</table>

(continued on next page)
SAFETY

All colonoscopy preparations may cause adverse events. The most common are electrolyte and fluid imbalance, as well as abdominal discomfort, bloating, dizziness, nausea and vomiting, adverse effects on colonic mucosa, and colonic-gas explosion. The choice of preparation is guided by comorbidities, concomitant medications, age concerns, patient preference, and cost to achieve safe and successful preparation. All oral bowel-preparation agents are contraindicated in the setting of obstruction, perforation, and severe ileus. Magnesium and phosphate preparations should be avoided in patients with renal failure.

Isosmotic preparations do not cause significant physiologic change in vitals signs, serum electrolytes, weight, and blood counts, which makes them suitable for patients with liver disease and ascites, renal failure, and congestive heart disease. However, an asymptomatic increase in plasma volume and exacerbation of congestive heart failure were reported. Other rare adverse events reported include pulmonary aspiration, Mallory-Weiss tear, esophageal perforation, pancreatitis, colitis, cardiac dysrhythmia, hyponatremia in patients with renal failure, and a syndrome of inappropriate antidiuretic hormone secretion. Rates of adverse events in a meta-analysis that compared PEG with NaP showed a statistically significant increase in pain reporting among patients who were taking a PEG preparation.

<table>
<thead>
<tr>
<th>TABLE 1 (continued)</th>
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</thead>
<tbody>
<tr>
<td><strong>Product (manufacturer)</strong></td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Fleet Bisacodyl (C.B. Fleet)</td>
</tr>
<tr>
<td>5-mg tablet</td>
</tr>
<tr>
<td>10-mg suppository</td>
</tr>
<tr>
<td>Dulcolax (Bisacodyl 5 mg; Boehringer, Petersburg, Va)</td>
</tr>
<tr>
<td>Senna (8.6 mg; AmerisourceBergen)</td>
</tr>
<tr>
<td>Senna syrup (8.8 mg per 5 mL; Altaire, Aquebogue, NY)</td>
</tr>
<tr>
<td>Sennokot (8.6 mg; Purdue Products LP, Stamford, Conn)</td>
</tr>
<tr>
<td>SennaPlus (50 mg; American Health Packaging, Columbus, Ohio)</td>
</tr>
<tr>
<td>Metoclopramide (5 mg; Teva, Philadelphia, Pa)</td>
</tr>
<tr>
<td>Gas-X (80 mg; Novartis, East Hanover, NJ)</td>
</tr>
<tr>
<td>Mylicon Infant Drops (40 mg per 0.6 mL; J &amp; J/Merck, Fort Washington, Pa)</td>
</tr>
<tr>
<td>Simethicone (80 mg; Advance, Ronkonkoma, NY)</td>
</tr>
<tr>
<td>Simethicone (125 mg; Rugby, Corona, Calif)</td>
</tr>
<tr>
<td>Mylanta (J &amp; J/Merck)</td>
</tr>
</tbody>
</table>

PEG, Polyethylene glycol; NaP, sodium phosphate.
*Adapted from Ref. 7.
†Approved only for small-volume treatment of constipation. The safety of the volume and dose for bowel preparation is not established, and the osmolarity may vary based on the volume of the solvent.
†The FDA recommends against use of over-the-counter oral NaP for bowel preparation.
C.B. Fleet ceased distribution and initiated a recall on December 11, 2008.
A black box warning was added in December 2008.
preparation and in dizziness and biochemical disturbances with NaP whereas there were no differences in nausea, vomiting, sleep disturbances, and perianal pain.34

Hyperosmotic preparations have the potential to cause fluid shifts by drawing fluid from the intravascular space, potentially resulting in hypovolemia and electrolyte disturbances. Most common with NaP are hyperphosphatemia, hypernatremia, hypocalcemia, and hypokalemia.10 In a meta-analysis of 9 trials, these biochemical disturbances were reported more frequently with NaP than with PEG preparations, although no clinical symptoms were associated with these laboratory abnormalities.34 Because of the potential for electrolyte abnormalities, NaP is not recommended in patients with renal disease, megacolon, bowel obstruction, ascites, and congestive heart disease.77 A review study examined the rates of adverse events with NaP in 28 trials: 26 with aqueous, and 2 with tablet NaP preparations that involved a total of 3022 patients.78 None of the patients in these trials had a major adverse event; however, patients with predisposing factors that could have led to adverse events were excluded. The study included reports of 6 fatalities, all associated with inappropriate dosing, and commented on 8 fatalities reported to the U.S. Food and Drug Administration (FDA) during a 6-year period, from 1997 to 2002. In comparison, during the same period, the FDA received reports on 6 fatalities with PEG preparations. In elderly patients, NaP was found to be associated with a decline in the glomerular filtration rate,79 whereas, in children, hyperphosphatemia was present to a higher degree than previously reported in adults.86 In addition, a recent series of reports describes acute phosphate nephropathy followed by chronic renal insufficiency after taking NaP for bowel preparation in patients with predominately normal renal function who were found to have calcium phosphate crystal deposition in renal tubules on kidney biopsy.80-82 In a series of 21 patients who developed acute phosphate nephropathy, potential etiologic factors included dehydration, increased age, hypotension, and concurrent use of an angiotensin-converting enzyme inhibitor or an angiotensin receptor blocker.83 These findings prompted the FDA to issue an alert in 2006 regarding the use of oral NaP for bowel preparation, particularly in individuals who were taking angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, or nonsteroidal anti-inflammatory drugs,84 and prompted some to advocate alternative colon-cleansing preparations for children and adolescents under 18 years of age.85 In December 2008, as a result of accumulating reports of renal injury, including patients without predisposing factors, the FDA recommended that over-the-counter NaP preparations not be used for bowel preparation. This prompted the manufacturer of over-the-counter NaP to undertake a voluntary recall of its product. Furthermore, a black box warning was added to prescription NaP products, and manufacturers were required to implement a risk evaluation and mitigation strategy, including a post-marketing trial, to further assess the incidence of renal injury.86 Other recent reports raise further concerns about the safety of this agent across a population and indicate the potential for significant long-term reduction in the glomerular filtration rate, particularly after 2 sequential doses of NaP.79,87

In general, the PEG preparation has been shown to preserve normal colon histology.88 However, a single randomized trial that compared PEG with no preparation described microscopic alterations, including inflammatory changes, loss of epithelial cells and mucus, and edema of the colonic mucosa, with PEG.89 NaP can alter the microscopic and macroscopic appearance of colonic mucosa, which may mimic inflammatory diseases.90-92 This has prompted some clinicians to avoid this preparation in patients with suspected inflammatory bowel disease or microscopic colitis.7

The nonabsorbable carbohydrates used for colon preparations, when fermented by colonic bacteria, can lead to production of the combustible gases hydrogen and methane. This can lead to colonic-gas explosion during electrocautery use.11 This complication was previously described with mannitol preparations and also more recently with sorbitol.93 In a 2007 review, a total of 10 cases of colonic-gas explosion during colonoscopy were reported, 6 with argon plasma coagulation and 4 with polypectomy, which resulted in 6 colon perforations and 1 death.11 In addition to ingestion of nonabsorbable carbohydrates, incomplete colon preparation, as is typically prescribed for flexible sigmoidoscopy,94 or inadequate preparation for colonoscopy can lead to production of a combustible level of gases.

**FINANCIAL CONSIDERATIONS**

Procedure cost is affected by inadequate preparation secondary to poor compliance or intolerance, which then increases the chance for an aborted procedure and the need for repeated colonoscopy.95,96 Product pricing for the list of products was obtained from the Red Book Pharmacy’s Fundamental Reference97 and expressed as average wholesale price (Table 1). The most expensive product is the NaP tablet preparation followed by PEG preparations, and the least expensive is aqueous NaP

**AREAS FOR FUTURE RESEARCH**

There is a need for development of new preparations for bowel cleansing that would achieve uniform and
complete cleansing with improved tolerability and reduced adverse effects. The existing regimens and their combinations need to be studied in large, prospective, randomized trials to establish equivalence and to determine minimally effective doses. In addition, further studies on patient preferences associated with alternative timing of dosing are needed. The efficacy and safety of newer PEG regimens, including PEG-3350 without electrolytes, prescribed with adjunctive carbohydrate liquids (eg, sports drinks) relative to existing preparations should be assessed. Bowel preparations have not been adequately studied for special populations (eg, extremes of age, pregnant women, and patients with comorbidities).

**SUMMARY**

The choice of bowel preparation for colonoscopy is influenced by cleansing effectiveness, safety, ease of administration and completion, adverse effects, patient tolerance, and cost. Currently, PEG-ELS and NaP are the most frequently used preparations in the United States. Recent action by the FDA highlights emerging safety concerns for NaP preparations. The selection of a bowel-cleansing regimen should be tailored to the individual patient based on clinical comorbidities and informed patient preference.

**REFERENCES**

41. Church JM. Effectiveness of polyethylene glycol antegrade gut lavage bowel preparation for colonoscopy. timing is the key! Dis Colon Rectum 1998;41:1223-5.
84. Lowry A, Hawes R, Deziel D. Addendum to a consensus document on bowel preparation before colonoscopy: prepared by a task force from the American Society of Colon and Rectal Surgeons (ASCRS), the American Society for Gastrointestinal Endoscopy (ASGE), and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). Gastrointest Endosc 2006;64:154.