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A consensus document on bowel preparation prior to colonoscopy:

Prepared by a task force from the American Society of Colon and Rectal Surgeons (ASCRS), the American Society of Gastrointestinal Endoscopy (ASGE), and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES)

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*Addendum I provides manufacturers' information for all products discussed in this document

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Colonoscopy is the current standard method for evaluation of the colon. Diagnostic accuracy and therapeutic safety of colonoscopy depends on the quality of the colonic cleansing or preparation. The ideal preparation for colonoscopy would reliably empty the colon of all fecal material in a rapid fashion with no gross or histologic alteration of the colonic mucosa. The preparation would also not cause any patient discomfort or shifts in fluids or electrolytes and would be inexpensive. (1) Unfortunately, none of the preparations currently available meet all of these requirements. (1,2)

A brief history of the evolution of bowel preparation for colonoscopy will be discussed followed by an evidenced based analysis of the various colonoscopy preparations, dosing regimens, and adjuncts currently utilized.

EVOLUTION OF BOWEL PREPARATIONS

Colonoscopy preparations evolved from radiologic and surgical preparations. (3) Early preparations used dietary limitations, cathartics, and enemas. Although these preparations cleansed the colon, they were time consuming (48-72 hrs), uncomfortable for the patient, and associated with fluid and electrolyte disturbances. (4) A rapid preparation used high volume (7-12L) per oral gut lavage with saline/electrolyte solution. This was also associated with severe fluid and electrolyte shifts and poor patient tolerance. In 1980, Davis et al. formulated polyethylene glycol (PEG), an osmotically balanced electrolyte lavage solution. (5) The standard 4L dosing regimen given the day before the procedure was established as safe and effective. (6-8) PEG quickly became the “gold standard” for colonoscopy. However, poor compliance related to the salty taste, the smell from the sulfates, and the large volume of fluids required led to modifications of the PEG solutions and their dosing recommendations and reevaluations of other osmotic laxatives (e.g. sodium phosphate). (9-16) Chang et al. developed a method of pulsed rectal irrigation combined with magnesium citrate. (17) These regimens and their utilization continue to evolve (18-39). More recent studies have focused on identifying the “ideal” preparation (**Table 1**) including such parameters as taste, electrolyte supplementation, the timing of doses, and the division of doses.

With this historical background and the precedent of an ASGE technology committee report (40), this document reviews the available evidence in order to create guidelines for bowel preparation prior to colonoscopy. The various studies in the literature have been graded according to the Levels of Evidence Grade Recommendation scale proposed by Cook et al (**Table 2**). (41)

REGIMENS FOR COLONIC CLEANSING PRIOR TO COLONOSCOPY

Diet

Dosing: Dietary regimens characteristically incorporate clear liquids and low residue foods over 1-4 days. Regimens typically incorporate dietary changes, and oral cathartic and/or additional cathartic enemas. (42) A cathartic such as magnesium citrate or senna extract is often used on the day prior to the procedure. Tap water enemas are administered on the morning of and occasionally on the evening prior to the procedure.

Evidence: Much of the evidence supporting these regimens comes from studies of colon cleansing for radiography. Although the individual components of these preparations vary widely, the combination of dietary restrictions and cathartics has proven to be safe and effective for colonic cleansing during colonoscopy. (6) In a recent study of in-patients undergoing colonoscopy, a clear liquid diet before administration of the bowel preparation was the only diet modification that improved the quality of preparation. (43) Although prolonged dietary restrictions and cathartics are effective, these regimens are less than ideal because of the time commitment required.

Recommendations: Dietary modifications, such as a clear liquid diet, alone are inadequate for colonoscopy. However they have proven to be a beneficial adjunct to other mechanical cleansing methods (Grade IIB).

Enemas

Dosing: Tap water or sodium phosphate enemas are administered on the evening prior or the morning of the procedure. For colonic cleansing, they are usually administered in conjunction with dietary restrictions or cathartics. In patients with poor or incomplete cleansing, one or two sodium phosphate enemas are useful in washing out the distal colon. Enemas are useful in washing out the distal segment of bowel in patients with a proximal stoma or a defunctioned distal colon (e.g. Hartman’s). Various commercial enema preparations are discussed in the adjunct section.

Evidence: The evidence is mostly anecdotal with no recent prospective trials (Grade 3B).

Recommendations: Use enemas in patients who present to endoscopy with a poor distal preparation and in patients with a defunctionalized distal colon.

High Volume Gut Lavage

Dosing: Per oral gut lavage with high volumes (7-12L) of saline solution or balanced electrolyte solutions with or without a nasogastric tube have been used for colonic preparation. (2) Mannitol was used in early formulations but abandoned secondary to bacterial fermentation into hydrogen and methane gas, which can cause explosion when electrocautery is used. (1,44)

Evidence: Although these regimens are effective in cleansing the colon, they are poorly tolerated. Administration of high volume unbalanced solutions can result in dramatic fluid and electrolyte shifts. There have also been anecdotal reports of complications following high volume infusion through a nasogastric tube. (45)

Recommendations: Neither high volume nor unbalanced solutions such as mannitol should be used for colonic preparation (Grade IA). In addition, caution should be exercised when using nasogastric tubes for the administration of any bowel preparation infusion (Grade V).

Rectal Pulsed Irrigation

Per rectal pulsed irrigation in combination with per oral ingestion of 10 oz of magnesium citrate the night before the colonoscopy is another potential preparation. The patient is given a 30-minute infusion of short pulses of warm tap water via the rectum through a rectal tube immediately before the colonoscopy. Disadvantages to this regimen are that is it time consuming and requires skilled nursing to administer, making it expensive to use. .

Evidence: Chang et al. (17) developed this regimen and compared it to PEG. No significant differences in quality of colonic cleansing were demonstrated between these two methods.

Recommendations: Rectal pulsed irrigation administered immediately prior to the procedure combined with magnesium citrate given the evening prior to the procedure is a reasonable alternative to full volume (4L) PEG in those individuals who cannot tolerate per oral administration of PEG (Grade IIB).

PEG-ELS (Polyethylene Glycol-Electrolyte Lavage Solution)

PEG is a non-absorbable solution that should pass through the bowel without net absorption or secretion. Significant fluid and electrolyte shifts are therefore avoided. Large volumes (4L) are still required to achieve a cathartic effect.

Products:

- Colyte -- Flavors: Cherry, Citrus-Berry, Lemon-Lime, Orange, Pineapple
- Golytely -- Flavors: Pineapple

Dosing: No solid food for at least two hours prior to ingestion of the solution. 240 mL (8 oz.) every 10 minutes until rectal output is clear or 4 L are consumed. Dosage for nasogastric administration is 20-30mL/min (1.2-1.8L/hr). (45)

Evidence: PEG is more effective and better tolerated than the diet combined with cathartic regimens that were used prior to 1980. (6-8,46,47) PEG is also safer and more effective than high volume balanced electrolyte solutions. (48) PEG is safer (less production of hydrogen gas), more effective, and better tolerated by patients than mannitol-based solutions. (49) Although PEG is generally well tolerated, 5-15% of patients do not complete the preparation because of poor palatability and/or large volume. (32,50) The additional use of enemas does not offer any improvement in the efficacy of PEG solutions, yet increases patient discomfort. (51) The timing of PEG doses has also proven to be important to the quality of the bowel preparation. PEG taken in divided doses (3L the evening prior and 1L the morning of the procedure) was demonstrated to be as effective as and better tolerated than the standard 4L dose given one day prior to the procedure. (52) The timing of the preparation in relation to the colonoscopy is also significant. In one study, consumption of the PEG solution less than 5 hours before the procedure resulted in better preparation than when given more than 19 hours before the procedure. (24) Additional studies have continued to show that divided dose regimens are superior to single dose regimens. One recent study suggests that the method and/or timing of administration is more important in determining quality of the preparation than is dietary restriction. (53) The addition of prokinetic agents to PEG administration has not been shown to improve patient tolerance or colonic cleansing. (54,55) (36) Similarly, bisacodyl administration does not significantly improve colonic cleansing or overall patient tolerance when used as an adjunct with full volume (4L) PEG. (56) PEG is relatively safe for patients with electrolyte imbalance and for patients who cannot tolerate a significant fluid load (renal failure, congestive heart failure, or advanced liver disease with ascites). (38) In addition, PEG gut lavage has proven to be the preferred method for colonic cleansing in infants and children. (57-59)

Recommendations: PEG is a faster, more effective, and better-tolerated method for cleansing the colon than a restricted diet combined with cathartics, high volume gut lavage, or mannitol (Grade IA). PEG is safer than osmotic laxatives/NaP for patients with electrolyte or fluid imbalances such as renal or liver insufficiency, congestive heart failure, or liver failure and is therefore preferable in these patient groups (Grade IA). Divided dose PEG regimens (2-3L given the night before the colonoscopy and 1-2 L on the morning of procedure) are acceptable alternative regimens that enhance patient tolerance (Grade IIB). Cleansing preparations for colonoscopies performed in the afternoon should instruct that at least part of the PEG solution be given the morning before the procedure (Grade IIB). Enemas, bisacodyl, and metaclopramide as adjuncts to the full volume of PEG have not been demonstrated to improve colonic cleansing or patient tolerance and are therefore unnecessary (Grade IIB).

SF-ELS (Sulfate Free-Electrolyte Lavage Solution)

PEG-based lavage solution without sodium sulphate was developed by Fordtran et al. (60) in an attempt to improve the smell and taste of PEG solutions. The improved taste was due to a decrease in potassium concentration, increase in chloride concentration, as well as a 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 PEG. (61)

Products:

- Nulytely -- Flavors: Cherry, Lemon-lime, Orange, Pineapple
- TriLyte -- Flavors: Cherry, Citrus-Berry, Lemon-lime, Orange, Pineapple. *Dosing*: No solid food for at least 2 hours prior to taking the solution. 240 mL (8 oz.) every 10 minutes until rectal output is clear or 4L are consumed. Dosage for nasogastric administration is 20-30mL/min (1.2-1.8 L/hr). Pediatric (older than 6 months of age) dose is 25mL/kg/hr until rectal effluent is clear. (45)

Evidence: SF-PEG is less salty, more palatable, and comparable to PEG in terms of effective colonic cleansing and overall patient tolerance. (9)

Recommendations: SF-PEG is comparable to PEG in terms of safety, effectiveness, and tolerance. SF-PEG is better tasting, but still requires the consumption of 4L in its standard regimen. SF-PEG is an acceptable alternative lavage solution when a PEG-based lavage solution is required (Grade IIB).

Low Volume PEG/PEG-3350 (Polyethylene Glycol-3350) and Bisacodyl Delayed- Release Tablets

Low volume PEG solutions were developed in an attempt to improve patient tolerance. In order to reduce the amount of volume of lavage solution required and reduce volume-related symptoms such as bloating and cramping while maintaining efficacy, bisacodyl and magnesium citrate are administered.

Products:

- Halflytely -- Flavors: Lemon-lime

Dosing: Only clear liquids on the day of the preparation. Dosage is 4 bisacodyl delayed-release tablets (5mg) at noon. Wait for bowel movement or maximum of 6 hours. 240mL (8oz.) every 10 minutes until 2L are consumed. (45)

Evidence: Multiple studies have compared full volume (4L) PEG with low volume (2L) PEG combined with magnesium citrate or bisacodyl. These studies have demonstrated equal efficacy of colonic cleansing, but with improved overall patient tolerance. (26,62)

Low volume PEG without any dietary restrictions has recently been suggested to provide better quality colon cleansing than whole-dose with no significant impact on either tolerability or adverse effects. (63)

Recommendations:

Two liter PEG regimens combined with bisacodyl (i.e. Halflytely) or magnesium citrateare equally effective when compared with standard 4L PEG regimens but are better tolerated and therefore may be the PEG preparation of choice (Grade IA). Additional studies comparing 2L regimens with NaP would be beneficial.

Low Volume PEG-3350 and Bisacodyl Delayed- Release Tablets

An additional low-volume PEG 3350 without electrolytes with adjuncts such as bisacodyl has also been used.

Products:

- Miralax

Dosing: Clear liquids only the day of the preparation. Dosage is 4 bisacodyl delayed-released tablets (5 mg) at noon. Wait for bowel movement or maximum of 6 hours. 240mL (8oz.) of clear liquid containing 1 capful of Miralaxevery 10 minutes until 2L are consumed.

Evidence: studies that have compared full-volume (4L) PEG with low-volume (2L) PEG 3350 combined with

bisacodyl have clearly demonstrated an equal efficacy in terms of colonic cleansing and improved overall patient tolerance.

Recommendations: Two-liter PEG 3350 regimens combined with bisacodyl (i.e. Miralax) are equally effective when compared with standard 4L PEG (Grade IA).

Aqueous Sodium Phosphate

Aqueous NaP is a low-volume hyperosmotic solution which contains 48g (400mmol) of monobasic NaP and 18 g (130mmol) of dibasic NaP per 100 ml. (64) The NaP osmotically draws plasma water into the bowel lumen to promote colonic cleansing. Significant fluid and electrolyte shifts can occur. Sodium phosphate must be diluted prior to drinking to prevent emesis and must be accompanied by significant oral fluid to prevent dehydration. Patients with compromised renal function, dehydration, hypercalcemia, or hypertension with the use of Angiotensin-converting Enzyme (ACE) Inhibitors, or Angiotensin receptor blockers (ARBs) have experienced phosphate nephropathy after use of oral sodium phosphate solutions. (65) The effects seem to be age and dose related. Linden and Waye (66) described the pharmacologic properties of NaP. The mean onset of bowel activity was 1.7 hours after the first dose and 0.7 hours after the second dose. The mean duration of action was 4.6 hours after the first dose and 2.9 hours after the second dose. Bowel activity ceased within 4 hours in 83% of patients and within 5 hours in 87%.

Products:

- Fleets

Dosing: Only clear liquids can be consumed on the day of preparation. Two doses of 30-45mL (2-3tbsp) of oral solution are given at least 10-12 hours apart. Each dose is taken with at least 8 oz of liquid followed by an additional minimum of at least 16 oz of liquid. The second dose must be taken at least 3 hours before the procedure. (45)

Evidence: Sodium phosphate has been compared to full volume (4L) PEG in multiple studies and has generally been found to be more or equally effective and better tolerated. Colonoscopists were also more likely to rate NaP as more acceptable than PEG-based solutions. (15) A divided dose NaP regimen in which the first dose is given the evening before the procedure and the second is given 10-12 hours later on the morning of the procedure has proven to be more effective than either a regimen utilizing two doses of NaP given the day before the procedure or a regimen utilizing full volume (4L) PEG. (14) This finding is consistent with the pharmacologic properties of NaP discussed above. A second split dose method for morning colonoscopies was demonstrated to be equally effective and as tolerable as standard 4L PEG. (20) The split dose of NaP was given at 1600 hrs and 1900 hours on the day before a morning colonoscopy. Bisacodyl was used as an adjunct in this regimen and given at 2200 hrs the evening before the colonoscopy. In one study, NaP was demonstrated to be more effective in colonic cleansing than Picolax(sodium picosulfate + magnesium citrate). (67) However, a second study offered conflicting data. (31) Because of its osmotic mechanism of action, NaP can result in potentially fatal fluid and electrolyte shifts, especially in elderly patients, patients with bowel obstruction, small intestinal disorders, poor gut motility, renal or liver insufficiency, congestive heart failure, or liver failure. (68) Nephrocalcinosis, as described previously, is also a concern. (65) Sodium phosphate can cause colonic mucosal lesions and ulcerations that may mimic inflammatory bowel disease. (69) Although contraindicated in children under the age of 5 years, several studies have assessed NaP in the pediatric population. (70) In these series, the efficacy of NaP was similar to PEG. (71,72) The efficacy of NaP in the elderly is similar to non-elderly adults and comparable to PEG. (70,71) The addition of cisapride does not result in any improvement in colon cleansing or

patient tolerance. (36) Agents that counteract the fluid and electrolyte shifts of NaP have proven to be successful, at least to a limited degree. In one study, the addition of a carbohydrate electrolyte rehydration solution resulted in less intravascular volume contraction. (73) In another study, E-lytesolution was shown to enhance both patient tolerance and the overall efficacy of NaP. (74) The addition of any carbohydrates to a bowel preparation may increase the production of explosive gases. Compared with the 40-tablet NaP regimen, aqueous NaP is better tolerated and more effective. (33) Further studies comparing the newer 28 and 32 tablet regimens with aqueous NaP are pending publication.

Recommendation: Aqueous NaP colonic preparation is an equal alternative to PEG solutions except for pediatric and elderly patients, patients with bowel obstruction and other structural intestinal disorders, gut dysmotility, renal or liver insufficiency, congestive heart failure, or liver failure (Grade IA). Dosing of aqueous NaP should be 45 ml in divided doses, 10-12 hours apart with one of the doses taken on the morning of the procedure (Grade IIB). Aqueous NaP is the preferable form of NaP at this time (Grade IIB). Apart from anecdotal reports, the addition of adjuncts to the standard NaP regimen has not demonstrated any dramatic effect on colonic cleansing preparation. Carbohydrate-electrolyte solutions such as E-Lytemay improve safety and tolerability.

Tablet Sodium Phosphate

Thetablet form of sodium phosphate was designed to improve the taste and limit the volume of liquid required. The results of two large, identically designed, Phase III multicenter randomized investigator-blinded trials that compared tablet sodium phosphate with 4L PEG regimens (21) were the basis for FDA approval in 2000. Each 2gm tablet contains 1500mg of active ingredients (monobasic and dibasic NaP) and 460 mg of microcrystalline cellulose as a tablet binder. The amount of active ingredient in this regimen is comparable to the standard aqueous NaP regimen. Microcrystalline cellulose is a non-absorbable inert polymer and is therefore insoluble in the gastrointestinal tract. (75) The remnants of this polymer can be visualized during colonoscopy and may interfere with the examination of the bowel mucosa. Therefore, reduced amounts of microcrystalline cellulose may help visualize the colonic mucosa. In 2001, a laboratory study demonstrated the beneficial effects of ginger ale when administered with Visicoltablets. This study attempted to provide a scientific basis for the clinical observation that ginger ale facilitates the removal of microcrystalline cellulose from the colon after the administration of Visicolprior to colonoscopy. (76)

Products:

- Visicol

Dosing: Dosage is 32-40 tablets; 20 tablets on the evening before the procedure and 12-20 tablets the day of the procedure (3-5 hours before). The 20 tablets are taken as 4 tablets every 15 minutes with 8oz of clear liquid. (45). Note: Bisacodyl is prescribed by some physicians as an adjunct.

Evidence: The Phase III trials in which tablet NaP regimens were compared to 4L PEG regimens demonstrated equal colon cleansing with fewer side effects. (21) Tablet NaP has been compared to aqueous NaP in multiple studies. Balaban et al found that liquid or aqueous NaP is better tolerated and more effective than tablet NaP. (33) Aronchick et al (34) found that tablet NaP is as safe and effective as Colyteand aqueous NaP and greatly preferred by patients. Two problems were identified with the initial 40-tablet regimen. Firstly, the inactive ingredient microcrystalline cellulose produces a residue that obscures the mucosal surface. Secondly, a large number of tablets (41) need to be ingested in a short period of time. These problems have been overcome by the reduction in the amount of microcrystalline cellulose per tablet (74) by a reduction in the number of tablets needed to complete the preparation from 40 to between 28 and 32 tablets. (22) Studies comparing liquid NaP

and a 2L PEG regimen with sodium phosphate tablets are pending publication; studies on adjunct therapies are currently lacking.

Recommendation: The improved taste and palatability of tablet NaP as compared to aqueous NaP has not translated into improved overall patient tolerance (Grade IA). The reduced amount of microcrystalline cellulose allows for better visualization of the colonic mucosa with less need for colonic irrigation (Grade IVB). Efficacy is maintained despite decreasing the number of tablets required to complete the preparation (Grade IIB), significantly improving patient tolerance.

ADJUNCTS TO COLONIC CLEANSING PRIOR TO COLONOSCOPY

Flavoring

There have been many attempts to improve the flavor of both PEG-electrolyte solutions and NaP solutions. As a result, PEG-electrolyte solutions are available in multiple flavors such as cherry, citrus-berry, lemon-lime, orange, and pineapple. In addition, the sulfate salts have been removed from HalfLytely and NuLytely, resulting in a less salty taste and avoidance of the “rotten egg” smell. Gatorade, Crystal Lite, and carbohydrate-electrolyte solutions have been used to improve palatability in both PEG and NaP solutions. Ginger Ale and water are used with NaP to improve the taste. However, improved flavor does not necessarily equate to improved tolerance. (77) Special care must be taken to avoid altering the osmolarity of the preparation or adding substrates to the preparation which can metabolize into explosive gases (45,74) or alter the amount of water and salts absorbed.

Nasogastric/Orogastric Tube Administration of Colonic Preparations

Nasogastric tubes have been used to instill colonic preparations primarily PEG-electrolyte based solutions in both children and adults. In addition to the potential complications related to placement of the nasogastric tube, case reports have demonstrated the potential for severe life threatening complications such as aspiration. (38)

Carbohydrate-Electrolyte Solutions

Products:

- Generic formulations of carbohydrate-electrolyte solutions also available
- Gatorade
- E-Lyte

Carbohydrate-electrolyte solutions have been used in combination with both PEG solutions and NaP to make the preparation more palatable and, in the latter, to avoid the severe electrolyte/fluid shifts. Combining PEG 3350 laxative powder (Miralax) and Gatoradehas been shown to improve the taste and tolerability of the preparation. (78) E-Lytecombined with NaP was demonstrated to improve overall tolerability and reduce the degree of volume contraction, hypokalemia, and the need for intravenous rehydration.(74)Although beneficial, the addition of these carbohydrate-based solutions is associated with a theoretical risk of cautery-induced explosion if these carbohydrates are metabolized by colonic bacteria into explosive gases.

Enemas

Products:

- Tap Water
- Soap Suds
- Fleet
- Fleet -- Bisacodyl
- Fleet -- Mineral Oil

Prior to the development of PEG, enemas were an essential component of colonic preparation. However, conclusive evidence has demonstrated that enemas do not improve the quality of bowel cleansing, yet significantly increase patient discomfort. (51) Enemas may still play a role in the patient who presents for colonoscopy with a poor preparation.

Metaclopramide

Products:

- Reglan
- Generic formulations also available

Metaclopramide is a dopamine antagonist gastroprokinetic that sensitizes tissues to the action of acetylcholine. This results in increased amplitude of gastric contraction, increased peristalsis of the duodenum and jejunum, and does not change colonic motility. Metaclopramide used as an adjunct with PEG has been shown to reduce nausea and bloating but not improve colonic cleansing. (54) However, a second study did not reveal any advantage with regards to colonic cleansing or patient tolerance. (55)

Simethicone

Products:

- Gas-X
- Mylicon
- Mylanta
- Generic formulations also available

Simethicone is an anti-flatulent, anti-gas agentthat has been used as an adjunct to colonoscopy preparations. The use of simethicone as an adjunct to PEG-electrolyte solution to eliminate foam formation after colonoscopy preparation and improve visualization during colonoscopy has been studies.(79) Simethicone reduced foaming and improved tolerability and improved efficacy (i.e. reduction in residual stool at time of colonoscopy). Howerver, the mechanism of action of simethicone was unclear. A subsequent study also showed a reduction in bubble formation seen during colonoscopy and an improvement in overall tolerability. (80)

Bisacodyl

Bisacodyl is a poorly absorbed diphenylmethane that stimulates colonic peristalsis. (35) Bisacodyl used as an adjunct with high volume balanced solution decreased the duration of whole gut irrigation although no significant difference in colon cleansing was identified. (81) Bisacodyl, when used as an adjunct with PEG, has demonstrated no significant difference in the quality of the preparation or amount of residual colonic fluid during

colonoscopy. (82,83) Bisacodyl and magnesium citrate are used as adjuncts to PEG solutions and have allowed for less volume of PEG necessary for colonic cleansing. (18,26) Afridi et al. studied bisacodyl as an adjunct with NaP given in split doses the evening before the procedure. (20) This combined regimen was found to be equally effective and tolerable as standard 4L PEG. Anecdotally, bisacodyl has been used as an adjunct for aqueous and tablet NaP, although further studies are necessary.

Saline Laxatives:

Products:

- Magnesium citrate
- Picolax (sodium picosulfate/magnesium citrate)

Magnesium citrate is a hyperosmotic saline laxative that increases intraluminal volume resulting in increased intestinal motility. Magnesium also stimulates the release of cholecystokinin which causes intraluminal accumulation of fluid and electrolytes and promotes small bowel and, possibly, colonic transit. Since magnesium is eliminated from the body solely by the kidneys, magnesium citrate should be used with extreme caution in patients with renal insufficiency or renal failure. Two studies by Sharma et al. utilized magnesium citrate as an adjunct to PEG. (18,62) The addition of magnesium citrate allowed for less PEG solution (2L) to be used in order to achieve the same result. Thus, the 2L volume PEG regimen was significantly better tolerated by patients.

Saline laxatives that use sodium picosulfate and magnesium citrate as the active ingredients are available primarily in the United Kingdom. Bowel preparations with this regimen have been compared to both PEG (84) and sodium phosphate. (66) Picolaxwas found to be equally effective as PEG in terms of quality of preparation but more tolerable (less nauseating and easier to finish). (85) Conflicting data concerning NaP compared to Picolaxhave been published. (31,66)

Senna

Products:

- X-Prep
- Senakot

Senna laxatives contain anthraquinone derivatives (glycosides and sennosides) that are activated by colonic bacteria. The activated derivatives then have a direct effect on intestinal mucosa, increasing the rate of colonic motility, enhancing colonic transit, and inhibiting water and electrolyte secretion. (39) Senna has been used as an adjunct to PEG regimens in a manner similar to that of bisacodyl. No differences were found between senna and bisacodyl when used as an adjunct in combination with PEG. (83) The adjunctive use of senna with PEG solutions has been demonstrated to improve the quality of bowel preparation (85) and to reduce the amount of PEG-ELS required for effective bowel preparation. (86)

EFFICACY

In order to assess the efficacy of bowel preparation, one must assess the relatively subjective appearance of the prepared colonic mucosa to a relatively objective parameter. Towards that end, several colonic cleansing

systems have been proposed. (11,34,87) However, no single system seems ideal in all situations.

SAFETY

The safety of the various bowel preparation protocols currently available for use prior to colonoscopy is related to the safety profile of the base agent, either PEG or NaP, and whether used in solid or liquid formulation. Generally speaking, all of the preparations detailed in this document have been demonstrated safe for use in otherwise healthy individuals without significant comorbid conditions. (21,88,89) Caution should be used in selecting a bowel preparation for patients with significant hepatic, renal, or cardiac dysfunction, and for those at the extremes of age.

The administration of isotonic PEG solution does not result in significant physiologic changes as measured by patient weight, vital signs, serum electrolytes, blood chemistries, and complete blood counts. (56,60,90) Isotonic PEG has been safely used in patients with serum electrolyte imbalances, advanced hepatic dysfunction, acute and chronic renal failure, and congestive heart failure. PEG does not alter the histologic features of colonic mucosa and may be used in patients suspected of having inflammatory bowel disease without obscuring the diagnostic capabilities of colonoscopy or biopsy analysis. (91)

Rare adverse events in patients receiving PEG have been reported, and include nausea with and without vomiting, abdominal pain, pulmonary aspiration, Mallory-Weiss tear, PEG-induced pancreatitis and colitis, lavage-induced pill malabsorption, cardiac dysrhythmia, and the syndrome of inappropriate antidiuretic hormone. (2,92-94) An increase in plasma volume has been shown to occur in some individuals with concomitant disease states that predispose them to fluid retention. (95,96) Adverse effects may occur less frequently in association with preparation regimens that use a reduced volume of PEG. (97) Some drug interaction databases raise concerns when PEG solutions, especially Half-lytelyare prescribed for patients taking ACE inhibitors and/or potassium-sparing diuretics because of the small amount of potassium present in this preparation solution. Although this problem raises a theoretic concern for hyperkalemia in these patients, no clinical reports of adverse outcomes were available as of this writing.

The use of NaP is associated with physiologically significant, although rarely clinically meaningful, changes in volume status and electrolyte abnormalities. Sodium phosphate is contraindicated in patients with serum electrolyte imbalances, advanced hepatic dysfunction, acute and chronic renal failure, recent myocardial infarction, unstable angina, congestive heart failure, ileus, intestinal malabsorption, and abdominal ascites. (20,27,37,95,98-102) Sodium phosphate preparations have been shown to alter both the macroscopic and microscopic features of intestinal mucosa, and induce aphthoid erosions similar to those seen in inflammatory bowel disease, which may obscure the diagnosis of IBD. (103,104) For this reason, many clinicians avoid using NaP preparations in patients undergoing diagnostic colonoscopy for suspected inflammatory bowel disease or microscopic colitis.

NaP is available as a bowel preparation for colonoscopy in both liquid and solid tablet form. The following adverse events are characteristic of both formulations. Serum electrolyte abnormalities and extracellular fluid volume is altered, initially by increasing fluid retention, and then causing significant losses of both fluid and electrolytes in the stool effluent. (39,105) The significant volume contraction and resultant dehydration seen in some patients using NaP preparations may be lessened by encouraging patients to drink fluids liberally during the days leading up to their procedure, especially during their preparation. (98) Although usually asymptomatic, hyperphosphatemia is seen in as many as 40% of healthy patients completing NaP preparations, and may be significant in patients with renal failure. (58,106) Up to 20% of patients using NaP preparations develop hypokalemia; in addition, NaP has been shown to cause elevated blood urea nitrogen levels, decreased exercise

capacity, increased plasma osmolality, hypocalcemia, (105,107) and significant hyponatremia and seizures. (108) These significant blood chemistry abnormalities are more profound in children; therefore, NaP should not be used in children with acute and chronic renal failure, congestive heart failure, ileus, and abdominal ascites. Rare adverse events such as nephrocalcinosis with acute renal failure have also been reported after NaP preparation for colonoscopy. (65, 109)

SPECIAL CONSIDERATIONS

Inadequate bowel preparation

Inadequate bowel preparation for colonoscopy can result in missed lesions, cancelled procedures, increased procedural time, and a potential increase in complication rates. One study examined the possible causes for poor preparations. (110) Surprisingly, less than 20% of patients with an inadequate colonic preparation reported a failure to adequately follow preparation instructions. Independent predictors of an inadequate colon preparation included a later colonoscopy starting time, failure to follow preparation instructions, inpatient status, a procedural indication of constipation, use of tricyclic antidepressants, male gender, and a history of cirrhosis, stroke, or dementia. Anecdotally, a poor preparation following a PEG preparation is usually liquid and more easily managed than a preparation following NaP that tends to be thick and tenaciously adhered to the mucosa. There is no published information on the management of the patient who has received a colonoscopy preparation that has been deemed inadequate. Regardless of the preparation selected, the patient and physician must be aware of potential financial obligations of a repeat colonoscopy and preparation. Specifically, the patient may be required to pay an additional co-pay for each examination and the financial intermediary may deem one or both examinations unnecessary. In these instances, the patient may be responsible for payment in full for both examinations. The following are recommendations (all are grade D based on the Levels of Evidence Scale recommended by Cook et al) (41) on management of this clinical predicament. Identify whether the patient has consumed the preparation as prescribed. If not, it would be reasonable to repeat the same preparation, although not within 24 hours using sodium phosphate (NaP) due to the risk of toxicity. If the patient has properly consumed the preparation, reasonable options include repeating the preparation with a longer interval of dietary restriction to clear liquids, switching to an alternate but equally effective preparation (if the patient received PEG, change to sodium phosphate or vice versa), adding another cathartic such as magnesium citrate, bisacodyl, or senna to the previous regimen, or double administration of the preparation over a two-day period (with the exception of NaP). Combining preparations, for example PEG solution and sodium phosphate solution, has also been described with some success. (18)

Selection of Bowel Preparation Based on Co-morbidities

Elderly patients

Elderly patients tend to have poorer preparations, although one study found no difference in the adequacy of the colonic preparation between PEG and NaP solutions. (111) They are at an increased risk for phosphate intoxication due to decreased kidney function, medication use, and systemic and gastrointestinal diseases. Administration of NaP causes a significant rise in serum phosphate (112), even in patients with normal creatinine clearance. (113) Hypokalemia is more prevalent in frail patients. (114) However, NaP preparations may be safe in selected healthy elderly patients. (70)

Possible underlying inflammatory bowel disease

NaP preparations may cause mucosal abnormalities that mimic Crohn’s disease. (115,116) However, the

frequency of this problem is rare and may not mitigate against using NaP. This caveat is most important in the initial colonoscopic evaluation of patients with symptoms suspect for colitis.

Diabetes Mellitus

One study showed that patients with diabetes have significantly poorer preparations with PEG solutions than non-diabetics, although there is no evidence that NaP preparations are superior in this group. (117)

Pregnancy

The need for colonoscopy is uncommon during pregnancy, therefore the safety and efficacy of colonoscopy in these individuals is not well studied. However, invasive procedures are justified when it is clear that by not doing so could expose the fetus and/or mother to harm. The safety of PEG electrolyte isotonic cathartic solutions has not been studied in pregnancy. PEG solutions are FDA Category C for use in pregnancy, as defined in the FDA Current Category for Drug Use in Pregnancy, wherein no adequate and well-controlled studies have been undertaken in pregnant women and a limited number of animal studies have shown an adverse effect. The common use of PEG solutions such as Miralaxto manage constipation associated with pregnancy supports its safety as a bowel preparation. Sodium phosphate preparations, which are FDA Category C, may cause fluid and electrolyte abnormalities and should be used with caution. (35)

Recommendation: If the potential benefit of colonoscopy outweighs the small but potential risks, patients may be cleansed with PEG solutions or, in select patients, a NaP preparation may be used (Grade VD).

Pediatric population

While there are no “national standards” per se for pediatric bowel preparations for colonoscopy, review of the literature documents the three most commonly used preparations. The least commonly used preparation is the administration of two pediatric Fleetsenemas and X-prep(for age). A more widely used preparation includes Miralaxat 1.25mg/kg/day for 4 days, the last day of which the child is maintained on clear liquids. This regimen is mild, well tolerated, and relatively simple to administer. The simplest preparation, both for the parents and the child, is the administration of a sugar-free clear liquid diet the day prior and then nil per os for 8 hours prior to the colonoscopy. This regimen is combined with Fleetsphosphosoda at a dosage of 1.5 tablespoons for children less than 15kg and 3 tablespoons for children 15kg or more, the afternoon and then again the evening prior to the colonoscopy. Each of these preparations is safe and will adequately prepare the child’s colon for colonoscopy (GRADE 1A). (118-120)

Cost

Table 3 shows the cost of bowel preparation agents listed as average wholesale price (AWP) that is provided by the “Red Book” July 2005. As can be seen, the least expensive solution is oral sodium phosphate and the most expensive the tablet form of sodium phosphate. The various polyethylene glycol preparations are intermediate in cost. None of the bowel preparation agents has an associated CPT code that would allow for separate payment reimbursed by the patients’ insurance company or Medicare in an outpatient setting. In an inpatient setting, the reimbursement for these agents would be included in the DRG payment. Of note, patients’ compliance and adequacy of bowel preparation agents can affect the direct cost for colonoscopic examination. A cost analysis has shown that, imperfect bowel preparation could prolong the procedure time and increase the chance for aborted examination and repeat colonoscopy earlier than suggested or required by current practice standards. Therefore, imperfect bowel preparation led to a 12% increase in costs at a university hospital setting and a 22%

increase at a public hospital setting. (121) A meta-analysis performed on eight colonoscopist-blinded trials showed that the direct costs of colonoscopic examination (excluding the cost of bowel preparation agents) were $465 for NaP and $503 for PEG, assuming that the rates of re-examination secondary to incomplete bowel preparation for NaP and PEG were 3% and 8%, respectively. The results suggest that NaP is less costly than PEG with a more easily completed preparation. (15)

SUMMARY

Colonoscopy is the most commonly employed technique used for inspection of the colonic mucosa. The safety and effectiveness of colonoscopy in identifying important colonic pathology is directly impacted by the quality of the bowel preparation done in anticipation of the procedure. Physicians favor preparations associated with the best patient compliance in order to achieve the best results. Patients favor preparations that are low in volume, palatable, have easy to complete regimens, and are either reimbursed by health insurance or are inexpensive. Both patients and physicians favor preparations that are safe to administer in light of existing comorbid conditions and those that will not interact with previously prescribed medications. Aqueous NaP solutions, NaP tablets, and PEG solutions, especially low volume solutions, are all accepted and well tolerated by the majority of patients undergoing bowel preparation for colonoscopy. Physicians are advised to select a preparation for each patient based on the safety profile of the agent, either NaP or PEG, in light of the overall health of the patient, their comorbid conditions, and currently prescribed medications. In certain circumstances, such as bowel preparation in children and the elderly and renal insufficiency, it may be advisable to adhere to PEG-based solutions because of the risks of occult physiologic disturbances that may contraindicate the use of NaP-based regimens. A variety of other preparations, none of which seem as popular due to inferior efficacy and/or patient acceptance, remain available for use in other circumstances where bowel preparation is necessary. Many adjuncts to bowel preparation have been proposed but remain largely inefficacious and therefore cannot be recommended for routine use.

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Table 1: Randomized controlled trials

Author (Year)	**N**	**Study Groups**	**Main Outcome**
Cohen (1994) (13)	422	4l PEG **vs** 4l PEG (sulfate free) **vs** 90cc NaP	NaP better prep, better tolerated
Church (1998) (24)	317	4l PEG (night before) **vs** 4l PEG (day of procedure)	PEG day of procedure with better prep
El-Sayed (2003) (25)	187	3l PEG + liquid diet **vs** 3l PEG (split dose) + bisacodyl + minimal diet restriction	Split dose PEG with better prep, better tolerated
Adams (1994) (26)	382	4l PEG **vs** 2l PEG + bisacodyl	PEG + bisacodyl better tolerated, prep equal
Henderson (1995) (27)	242	4l PEG **vs** 90cc NaP	Prep similar, NaP better tolerated
Young (2000) (28)	323	2l PEG + bisacodyl **vs** 90cc NaP	NaP better prep, better tolerated
Poon (2003) (19)	200	2l PEG **vs** 90cc NaP	Prep + tolerance similar
Barclay (2004) (29)	256	135cc NaP **vs** 90cc NaP	135cc NaP better prep, poorer tolerance

Author (Year)	N	Study Groups	Main Outcome
Law (2004) (30)	299	2 - 4l PEG **vs** 45cc NaP **vs** 90cc NaP	90cc NaP best prep, better tolerated
Schmidt (2004) (31)	400	Na picosulfate **vs** NaP	Prep equal, Na picosulfate better tolerated
Golub (1995) (32)	329	4l PEG **vs** 4l PEG + metoclopramide **vs** 90cc NaP	Preps equal, NaP better tolerated
Balaban (2003) (33)	101	90cc NaP (liquid) **vs** 40 tabs NaP (tablet)	Liquid NaP better prep, better tolerated
Aronchick (2000) (34)	305	4l PEG **vs** 90cc NaP **vs** 24-32 tabs NaP	Preps equal, NaP tabs better tolerated
Kastenberg (2001) (21)	845	4l PEG **vs** 40 tabs NaP	Prep equal, NaP tabs better tolerated
Afridi (1995) (20)	147	4l PEG **vs** 90cc NaP + bisacodyl	Prep equal, NaP + bisacodyl better tolerated
Frommer (1997) (14)	486	3l PEG **vs** 90cc NaP (day before) **vs** 90cc NaP (day before, day of procedure)	NaP day of procedure best prep, NaP better tolerated than PEG
Ell (2003) (35)	185	4l PEG (standard) **vs** 4l PEG (sulfate free) **vs** 90cc NaP	Standard PEG best prep, tolerance similar
Martinek (2001) (36)	187	*4l PEG **vs** *90cc NaP *(with/without cisapride)	PEG better prep, NaP better tolerated
Vanner (1990) (37)	102	4l PEG **vs** 90cc NaP	NaP better prep, better tolerated
Marschall (1993) (38)	143	4l PEG **vs** 90cc NaP	Prep equal, NaP better tolerated
Kolts (1993) (39)	113	4l PEG **vs** 90cc NaP **vs** 60cc Castor Oil	NaP best prep, better tolerated than PEG

Table 2: Levels of Evidence and Grade Recommendation (41)

Level	Source of Evidence
I	Meta-analysis of multiple well-designed, controlled studies, randomized trials with low-false positive and low-false negative errors (high power)
II	At least one well-designed experimental study; randomized trials with high false-positive or high false-negative errors or both (low power)
III	Well-designed, quasi experimental studies, such as nonrandomized, controlled, single-group, preoperative-postoperative comparison, cohort, time, or matched case-control series
IV	Well-designed, non-experimental studies, such as comparative and correlational descriptive and case studies
V	Case reports and clinical examples
Grade	Grade of Recommendation
A	Evidence of type I or consistent findings from multiple studies of type II, III, or IV
B	Evidence of type II, III, or IV and generally consistent findings
C	Evidence of type II, III, or IV but inconsistent findings

Level	Source of Evidence
D	Little or no systematic empirical evidence

Table 3: Cost of Bowel Preparation Agents Quantity Average Wholesale Price

Colyte®		
- flavored	3785 ml	$16.16
- non-flavored	3785 ml	$13.89
GlycoLax™	255 gm	$19.54
	527 gm	$39.06
GoLyltely®		
- flavored	4000 ml	$19.70
- non-flavored	4000 ml	$18.45
MiraLax™	255 gm	$21.73
	527 gm	$43.45
NuLytely®		
- flavored	4000 ml	$25.65
- non-flavored	4000 ml	$25.65
TriLyte®*		
- flavored	4000 ml	$25.63
Oral sodium phosphate (aqueous)	45 ml	$1.48
Fleet® Phosphosoda	90 ml	$2.65
Oral sodium phosphage (tablet)	100’s	$160.22 ($1.60/tablet)
Visicol™		$44-$66/preparation
Bisacodyl (tablet) 5 mg	100’s	$9.85 ($0.10/tablet)
Magnesium citrate (liquid)	300 ml	$1.43
Senna	100’s	$8.99 ($0.09/tablet)
Senna/Docusate (tablet)	100’s	$11.13 ($0.11/tablet)
Senna Plus®		
Metoclopramide (tablet) 5 mg	100’s	$32.00 ($0.32/tablet)
Fleet -- Enema	135ml	$0.80
Fleet -- Bisacodyl		
ECT, po 5mg	25’s	$2.90 (each)
SUP, RC, 10mg	4’s	$1.83 (each)
Fleet -- Bisacodyl Enema	37.5ml	$1.12
Fleet -- Mineral Oil	480ml	$1.88
Fleet -- Mineral Oil Enemas	135ml	$1.45
Enemeez -- Mini Enema	5ml (30’s)	$72.99**
Gas-X (80mg)	12’s	$1.88
	36’s	$4.67
Mylicon -- Infant Drops	15ml	$6.22
- 40mg/0.6ml	30ml	$10.36
Simethicone 80mg	100’s	$6.30 (each)
(Rugby) 125mg	60’s	$5.02 (each)
Mylanta	150ml	$2.63

Colyte®		
	360ml	$4.45
	720ml	$8.00
X-Prep -- Syrup	75ml	$13.59
X-Prep -- Bowel Evacuant	1 kit	$19.32 (each)
Kit-1, with Senokot-S, Halflytely and Bisacodyl	1 kit	$48.75 (each)
Tablet Bowel Prep Kit E-Lyte	20oz	$20.00**

*Only TriLyte® with Flavor Packs was listed in the Red Book®

Product pricing provided by manufacturers as listed in July 2005 (2003 Red Book®, American Academy of Pediatrics, Elk Grove Village, IL)

**Price listed on the internet

Addendum 1

Products and Manufacturers

Product	**Manufacturer**	**City, State**
Golytely	Braintree Laboratories	Braintree, MA
HalfLytely	Braintree Laboratories	Braintree, MA
Miralax	Braintree Laboratories	Braintree, MA
Nulytely	Braintree Laboratories	Braintree, MA
Fleet Mineral Oil	C.B. Fleet Company	Lynchburg, VA
E-Lyte	C.B. Fleet Company	Lynchburg, VA
Fleets Phosphosoda	C.B. Fleet Company	Lynchburg, VA
Fleet Bisacodyl	C.B. Fleet Company	Lynchburg, VA
Picolax	Ferring Pharmaceuticals	Berkshire, UK
Gatorade	Gatorade International	Chicago, IL
Mylanta	J&J/Merck Pharmaceuticals	Fort Washington, PA
Mylicon	J&J/Merck Pharmaceuticals	Fort Washington, PA
CrystalLite	Kraft Foods	Northfield, IL
Gas-X	Novaris Consumer Health Inc	Broomfield, CO
X-prep	Purdue Frederick	Norwalk, CT
Reglan	Robins Pharmaceutical	Eatontown, NJ
Visicol	Salix Pharmaceuticals	Morrisville, NC
Colyte	SchwarzPharm	Mequon, WI
TriLyte	SchwarzPharm	Mequon, WI

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