

Bowel Preparation before Elective Surgery

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Abstract

Keywords

- ▶ mechanical bowel preparation
- ▶ elective colorectal resection
- ▶ oral antibiotics

Mechanical bowel preps were initially thought to decrease the bacterial load of the colon and therefore decrease infection. Traditional bowel preps include osmotic, laxative, and combination regimen. Data demonstrate that mechanical bowel preps are generally equivalent; however, the addition of oral antibiotics may further reduce the risk of infection. Recent data suggest that mechanical bowel preparations may not be necessary, and that dietary restrictions before surgery may also be obsolete. In this review, the authors address the types of mechanical bowel preparations (MBPs), differences in outcomes between MBPs, the role of oral antibiotics and enemas, the benefits of no MBP, and dietary preparations for elective colon and rectal surgery.

Objectives: On completion of this article, the reader should be able to describe the outcomes of the recent randomized clinical trials on mechanical bowel preparation versus no preparation before elective colon and rectal surgical resections as well as detail the history and the benefits of oral antibiotics with bowel preparation in preventing surgical site infections.

Rationale for Bowel Preps

There are several potential or perceived advantages of mechanical bowel preparations (MBPs). Historically, the possibility of having the high bacterial load content of feces coming in contact with a newly performed anastomosis led to the construction of a defunctioning stoma when colon was not prepared. A MBP was also thought to clear the bowel lumen of stool and leave only gas. Theoretically, this would decrease the intraluminal pressure of hard, potentially impacted stool, and reduce ischemia at the new anastomosis. In laparoscopic surgery, an empty colon may be easier to manipulate than a colon full of stool. And certainly, when the surgeon knows he or she needs to rely on palpation to locate the lesion, having an empty colon is an advantage. However, in recent years, the necessity and benefits of a MBP have been

questioned and data supporting abandonment of this practice is mounting.

Types of Mechanical Bowel Preparations

MBPs are preparations that are taken by mouth to achieve clearance of the colonic contents. Although enemas and diet restrictions are also a mechanically driven way of lower intestinal cleansing, they are usually not classified as MBPs. There are three classes of cleansing methods: osmotic agents (absorbed and nonabsorbed), stimulant laxatives, and regimens that involve a combination of osmotics and laxatives. ▶ **Table 1** provides side-by-side comparisons of commercially-available and over-the-counter formulations of MBPs.

Osmotic agents act by pulling water into the colonic lumen and retaining the water that is ingested. Their mechanism is dependent on the osmolality of the agent relative to the tissue fluid. Metabolically inert molecules, such as magnesium citrate, are one type of osmotic agent, while nonabsorbed sodium-based salt solutions are another.

Sodium phosphate solutions are osmotic solutions that draw water into the colon lumen to achieve cleansing, but significant fluid and electrolyte changes can occur. Patients

Table 1 Mechanical bowel preparations used in colonoscopy and colon resections

Class of agent/ mechanism of action	Preparation/ formulation	Product brand name	Manufacturer's details	Recommended dosing
Osmotic cathartic				
	Sodium phosphate tablets	Visicol	Salix Pharmaceuticals, Morrisville, NC	3 Tablets every 15 min to total 20 tablets, repeat with 12–20 tablets 10–12 h later (at least 3 h before procedure)
		OsmoPrep	Salix Pharmaceuticals, Morrisville, NC	As above
	Aqueous sodium phosphate	Fleet	CB Fleet, Lynchburg, VA	30–45 mL of solution taken with 32 oz of liquid; repeat 10 h later
	Magnesium citrate			10 oz of magnesium citrate with 8 oz of water each hour for total of 4 h; repeat regimen 4 h later
Nonabsorbed osmotic agent				
	4-L PEG-ELS gastrointestinal lavage solution	GoLYtely	Braintree Laboratories, Holbrook, MA	240 mL every 10 min the evening before procedure
		Colyte	Schwarz Pharma, Inc., Milwaukee, WI	4 L taken as a single dose
	4-L SF-PEG solution	NuLYTELY	Braintree Laboratories, Holbrook, MA	3 L followed by 1 L 10–12 hours later (at least 3 h before procedure)
		TriLyte	Schwarz Pharma, Inc., Milwaukee, WI	As above
	2-L PEG + ascorbate	MoviPrep	Salix Pharmaceuticals, Morrisville, NC	240 mL every 15 min to total 1 L, followed by 16 oz of fluid; repeat regimen at least 3 h before procedure
Stimulant laxative (contact irritant)	Bisacodyl	Dulcolax	Boehringer Ingelheim Pharmaceuticals, Ridgefield, CT	2–4 (5 mg) tablets taken in a single dose
Combination osmotic/laxative	Sodium picosulfate/magnesium citrate (sodium picosulfate 0.01 g, magnesium oxide 3.5 g, citric acid 12.0 g per sachet), with the magnesium oxide and citric acid components forming magnesium citrate when the powder is dissolved	CitraFleet	Aptalis, Birmingham, AL	Powder form (sodium picosulfate 0.01 g, magnesium oxide 3.5 g, citric acid 12.0 g per sachet), with the magnesium oxide and citric acid components forming magnesium citrate when the powder is dissolved in water
		Picolax	Ferring Pharmaceuticals Ltd, London, UK	As above
Combination non-absorbed osmotic/laxative	2-L PEG-ELS gastrointestinal lavage solution + bisacodyl	Halflytely	Braintree Laboratories, Holbrook, MA	10 mg bisacodyl 5 h before 240 mL every 10 min to total 1 L, repeat 240 mL every 10 min to total 1 L

(Continued)

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Table 1 (Continued)

Class of agent/ mechanism of action	Preparation/ formulation	Product brand name	Manufacturer's details	Recommended dosing
				starting 3–4 h before procedure
	2-L PEG + bisacodyl	MiraLAX	Schering-Plough, Kenilworth, NJ	As above

Abbreviations: h, hour; min, minute; PEG, polyethylene glycol; PEG-ELS, polyethylene glycol with electrolytes, SF-PEG, sulfate-free polyethylene glycol. Source: Adapted from Beck DE. Mechanical bowel cleansing for surgery. *Perspect Colon Rectal Surg* 1994;7:97–114.

with compromised renal function, hypercalcemia, and hypertension requiring angiotensin-converting enzyme (ACE) inhibitor use have reported renal failure from phosphate nephropathic damage. Often, this damage is irreversible and worse at higher doses and older ages.¹

Polyethylene glycol (PEG) is the nonabsorbable osmotic agent most widely commercially available. There are two types of PEG solutions: electrolyte solutions and sulfate-free solutions without electrolytes. When the product includes electrolytes, it is composed of sodium 125 mmol/L, sulfate 40 mmol/L, chloride 35 mmol/L, bicarbonate 20 mmol/L, and potassium 10 mmol/L. The preparation is associated with a salty taste, but is relatively well tolerated. Moreover, it is not associated with fluid or electrolyte problems. The sulfate-free, electrolyte-free versions of PEG solution have an improved taste that may be associated with better tolerance. When given in 4-L regimens, patient tolerance of PEG solutions is poor due to palatability and volumes. Reduced volume options are available in a 2-L formulation (→ **Table 1**) and have been associated with an equivalent level of cleansing and better patient tolerance.²

Because PEG is a balanced solution that is not absorbed, it is safe for patients with electrolyte imbalances (i.e., renal failure patients) or patients who may not be able to tolerate fluid shifts (i.e., congestive heart failure patients, patients with ascites from liver disease). In addition, PEG solution is the method of choice for bowel cleansing of infants and children.

In adults, there are two strategies implemented with PEG MBPs to improve cleansing: split dosing of preparations, and addition of stimulant agents (bisacodyl) or prokinetic agents (metoclopramide). In split dosing, part of the preparation is given the night before and the remainder is given the morning of the procedure. These regimens have improved colon cleansing and better patient tolerability;² however, depending on the nothing-per-os (NPO) policies of the hospital and the anesthesia team, split dosing may cause scheduling challenges. Of note, PEG lavage consumed less than 5 hours before the procedure resulted in better cleansing than when it was given more than 19 hours before the procedure.³

Stimulant agents cause bowel wall contraction that aids in evacuation. In trials that use cathartic agents alone, only 75% of patients achieve adequate cleansing.⁴ When combined with enemas, dietary restrictions, or osmotic agents, the

use of these agents, especially when initiated 1 to 2 days before the procedure, are effective in achieving adequate cleansing of feces from the bowel lumen.

Differences in Outcomes between MBPs

There seems to be little difference in the adequacy of bowel preparation between the various types of solutions, especially when it comes to scores evaluated during colonoscopy. An example is a prospective, randomized trial by McKenna et al.⁵ The authors conducted a single-blinded noninferiority trial on 136 patients on the effect of different volumes of PEG solution (238 g PEG + 1.9 L Gatorade [PepsiCo, Purchase, NY] versus 236 g PEG in 4 L of electrolyte lavage solution) with an outcome measure of Boston Bowel Preparation Scale (BBPS) during colonoscopy. There were no differences in preparation BBPS scores or serum electrolytes between the two agents, but the lower volume Gatorade solution garnered a higher patient satisfaction score.⁵

When examining different types of bowel preparation in the context of elective surgery with an outcome measure of surgical site infection (SSI), Itani et al⁶ conducted a post hoc analysis of the role of MBP in a prospective randomized controlled antibiotic prophylaxis trial. They evaluated the effect of polyethylene glycol (PEG) and sodium phosphate (SP) MBPs on the rates of postoperative SSIs. The numbers of patients per MBP subgroup were roughly equal in each antibiotic group. The rates of bowel clearance were equal in both MBP subgroups (~92%). However, when stratifying for risk factors for SSI, the SP subgroup was favored over PEG (odds ratio [OR], 0.6; 95% confidence interval [CI], 0.43–0.85) in univariate analysis. Multivariate analysis also favored SP, but was not significant (OR, 0.69; 95% CI, 0.46–1.02).⁶

Role of Oral Antibiosis

There is little doubt among surgeons that administration of preoperative parenteral antibiotics prevents SSI and is covered elsewhere in this issue. What is less clear is the role of oral antibiotics and mechanical bowel prep in reduction of SSI. Colorectal resections have a higher SSI rate than other elective abdominal operations because of the high bacterial load present within the colon lumen, estimated to be 10¹² colony-forming units per gram of stool.⁷ Cleansing the colon

of gross fecal material is a logical strategy to reduce microbial contamination at the surgical site and potentially reduce infections.

The role of oral antibiotics in addition to mechanical bowel prep is controversial. A 2002 study by Lewis showed a decrease in the occurrence of infections in the surgical incision (17% to 5%) when oral antibiotics were added to MBP.⁸ This regimen consisted of standard MBP using sodium phosphate, completed by 6 PM, then followed by amikacin (2 g) and metronidazole (2 g) at 7 PM and 11 PM. Lewis then incorporated data of 12 other studies in a meta-analysis randomizing patients to oral antibiotics; all patients received a standard preoperative parental antibiotic regimen. The meta-analysis showed reduction in SSI for the mechanical-plus-oral bowel preparation in elective colon surgery. Similarly, a 2012 retrospective study conducted by Cannon et al showed a 57% decrease in surgical site infection when oral antibiotics plus mechanical bowel preparation were used in elective colon resections ($n = 9,940$).⁷ Bellows et al showed in their 2011 meta-analysis that the combination of oral non-absorbable and intravenous (IV) antibiotics reduced the incidence of wound infections after colorectal surgery by 43% compared with IV antibiotics alone.⁹

Conversely, a 2004 study by Espin-Basany et al showed no decrease in postoperative septic complications when three doses of oral, nonabsorbable antibiotics were given in addition to MBP. They did, however, find an increase in the amount of nausea, vomiting, and abdominal pain associated with the administration of the oral antibiotics.¹⁰

The oral antibiotic preparation that is the best tolerated and best studied is the original Nichols and Condon prep. The regimen is as follows:

- 1 g oral neomycin given at 2 PM, 3 PM, and 10 PM
- 1 g erythromycin base given at 2 PM, 3 PM, and 10 PM
- Metronidazole 500 mg given may be substituted for erythromycin for better tolerability. Metronidazole has excellent anaerobic activity, enterohepatic circulation, and has been shown to be clinically effective.¹¹⁻¹⁴

Use of Enemas as Preoperative Preparation

Enemas for rectal cleansing have been commonly used as part of MBP for colorectal procedures. Options for enemas include sodium phosphate, glycerin, or saline solutions. While in the United States they may be self-administered at home, in Europe, they are more commonly administered in the hospital, 2 to 4 hours before surgery.¹⁴ The theoretical benefit of rectal cleansing with enema solutions is that the reduction of fecal matter in the rectal vault prevents extrusion of bowel contents and mechanical obstruction during insertion of the stapling devices for anastomosis creation. This may be especially useful in rectal surgery, and it is commonly reported that physicians perform an on-table saline rectal washout before such procedures.¹⁶⁻¹⁸

In randomized trials, no clinical benefits were noted when comparing oral mechanical bowel preparation with enema use.^{19,20} Patients using large-volume glycerin enemas alone

were more frequently rated as having poor bowel preparations, but there was no increase in intraabdominal fecal soiling or infectious complications.¹⁹ A 2011 Cochrane Review also reported no difference in anastomotic or wound complications when enemas alone were used for bowel preparation.²¹

No Preparation

Although many continue to routinely use MBP for patients undergoing elective colorectal surgeries, many reports now indicate that this practice may be safely abandoned for most procedures and patients. Both clinical trials and retrospective reviews have found a trend toward increased infectious complications in patients who underwent MBP when compared with those who did not.^{16,17,22,23} There have also been reports of earlier return of bowel function and shorter hospital stays among patients who did not have MBP before surgery.^{5,22,24} The most recent large, multicenter trial, however, found that there was no difference between MBP and no-MBP groups in rate of anastomotic leak or severity of infectious complications.^{25,26} **Table 2** is adapted from Duncan;²⁷ it summarizes the randomized clinical trials^{26,28-39} on the MBP versus no-MBP issue. A 2011 Cochrane Review²² on MBP in elective colorectal procedures (18 randomized trials on $n = 5,805$ patients) did not detect any differences in rates of anastomotic leak or wound infections following colorectal procedures.²¹ Based on these conclusions, experts and national groups have called for the omission of MBP before elective colorectal procedures.^{18,40}

There may be some exceptions to this rule. In cases where a colonoscopy will be performed immediately before the resection, a bowel preparation may still be warranted. This is particularly true in patients with small (< 2 cm) and non-palpable tumors that may need to be located intraoperatively with a scope. These patients were frequently excluded from trials and therefore conclusions cannot be drawn on the safety of abandoning MBP in these circumstances.^{16,17}

Current Practices

Despite the numerous reports supporting the safety of colorectal procedures without mechanical bowel prep (MBP), physicians around the world have been slow to abandon the practice. In a 2002 survey of surgeons in the United States, 99% reported routinely prescribing a MBP before colorectal surgery, with 47% using oral sodium phosphate and 32% oral PEG solution.¹⁶ Three-quarters of surgeons also routinely used preoperative oral antibiotics in conjunction with their MBP and IV antibiotic prophylaxis.¹⁶ A study of almost 300 hospitals in Europe and the United States also found that 96% of patients admitted for a colorectal procedure underwent preoperative MBP.¹⁵ Recent reports from Switzerland and New Zealand are more in line with the recommendations to abandon MBP, with less than half of physicians reporting MBP use in colon procedures. However, even in these countries, MBP use is common during anorectal procedures (60-80%).^{41,42} Of note, more recent survey

Table 2 Comparison of randomized clinical trials on mechanical bowel prep versus no mechanical bowel prep on anastomotic leaks and wound infections 2000–2010

Study	No. of patients	MBP agent	Anastomotic leaks with MBP (%)	Anastomotic leaks without MBP (%)	P value	Wound infections with MBP (%)	Wound infections without MBP (%)	P value
Miettinen et al, 2000	267	PEG	3.8	2.5	0.72	3.6	2.3	0.72
Tabusso et al, 2002	47	Mannitol or PEG	20.8	0	0.04	8.3	0	0.49
Bucher et al, 2005	153	PEG	6.4	1.3	0.21	12.8	4	0.07
Ram et al, 2005	329	NaP	0.6	1.3	1	9.8	6.1	0.22
Fa-Si-Oen et al, 2005	250	PEG	5.6	4.8	0.78	7.2	5.6	0.79
Zmora et al, 2006	249	PEG	4.2	2.3	0.48	6.7	10.1	0.36
Pena-Soria et al, 2007	97	PEG	8.3	4.1	0.05	12.5	12.2	1
Jung et al, 2007	1343	PEG, NaP, enema	1.9	2.6	0.46	7.9	6.4	0.34
Contant et al, 2007	1354	PEG + bisacodyl or NaP	4.8	5.4	0.69	13.4	14	0.75
Leiro et al, 2008 (Argentina)	129	PEG or NaP	5.7	15.2	0.183	21.9	21.5	1
Moral et al, 2009 (Spain)	139	PEG or NaP or aqueous NaP	7.2	5.7	0.75	11.6	5.7	0.24
Van't Sant et al, 2010	449	PEG + bisacodyl or NaP	7.6	6.6	0.8	9	7	0.43
Scabini et al, 2010	244	PEG	5.8	4	0.52	9.2	4.8	0.18
Bretagnol et al, 2010	178	Oral senna solution and povidone-iodine enema	11	19	0.09	1	3	NS

Abbreviations: MBP, mechanical bowel prep; NaP, sodium phosphate; NS, nonsignificant; PEG, polyethylene glycol.
Source: Adapted with permission from Duncan JE, Quietmeyer CM. Bowel preparation: current status. *Clin Colon Rectal Surg* 2009;22(1):14–20.

studies have found that younger physicians, and a significant number of board-certified colorectal surgeons are more likely to have abandoned the practice of MBP before elective colorectal procedures.^{41,43}

Dietary Preparations for Elective Colon and Rectal Surgery

A review of studies in bowel preparation for colonoscopy recently challenged the importance of traditional dietary restrictions for adequate bowel preparation.¹⁸ The consumption of low-residue liquid supplements, low-residue meals, and even regular diets until the evening before surgery have been shown to be equivalent or better than the traditional 24-hour clear liquid diet before colonoscopy. In these studies, various PEG solutions were used for MBP and many investigators attributed the improved results of the relaxed dietary regimens to the improved ability for patients to tolerate and complete the full liquid prep. In one study, increasing consumption of high-residue food before colonoscopy was a predictor of poor colon preparation, indicating that there may be a limit before detrimental effects are seen.¹⁸ The current evidence from studies comparing MBP with no MBP in elective colorectal procedures also suggests that a regular diet may be safely maintained through the day before surgery.⁴⁴ Easing the dietary restrictions during preparation for colon surgery may result in equivalent or better bowel preparation before surgery when combined with PEG solution.

Conclusion

It is clear that MBP alone does not reduce SSIs in elective colon and rectal surgery. Clinical evidence supports the use of MBP as an adjunct to the use of the oral antibiotic bowel preparation. Overwhelmingly, the recent literature supports the use of the oral antibiotic bowel preparation and systemic preoperative prophylactic antibiotics together for the prevention of SSIs in elective colon and rectal surgery.

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