Preoperative bowel preparation for patients undergoing elective colorectal surgery: a clinical practice guideline endorsed by the Canadian Society of Colon and Rectal Surgeons

Cagla Eskicioglu, MD, MSc[*†]
Shawn S. Forbes, MD, MSc[*†]
Darlene S. Fenech, MD, MSc[*‡]
Robin S. McLeod, MD[*†§]
For the Best Practice in General Surgery Committee

From the *Department of Surgery, University of Toronto, the †Zane Cohen Digestive Diseases Clinical Research Centre and Mount Sinai Hospital, the ‡Sunnybrook Health Sciences Centre and the §Department of Health Policy, Management and Evaluation, University of Toronto, and the Samuel Lunenfeld Research Institute, Toronto, Ont.

Accepted for publication
May 19, 2009

Correspondence to:
Dr. R.S. McLeod
Mount Sinai Hospital, Rm. 449
600 University Ave.
Toronto ON M5G 1X5
rmcleod@mtsinai.on.ca

Background: Despite evidence that mechanical bowel preparation (MBP) does not reduce the rate of postoperative complications, many surgeons still use MBP before surgery. We sought to appraise and synthesize the available evidence regarding preoperative bowel preparation in patients undergoing elective colorectal surgery.

Methods: We searched MEDLINE, EMBASE and Cochrane Databases to identify randomized controlled trials (RCTs) comparing patients who received a bowel preparation with those who did not. Two authors reviewed the abstracts to identify articles for critical appraisal. We used the methods of the United States Preventive Services Task Force to grade study quality and level of evidence, as well as formulate the final recommendations. Outcomes assessed included postoperative infectious complications, such as anastomotic dehiscence and superficial surgical site infections.

Results: Our review identified 14 RCTs and 8 meta-analyses. Based on the quality and content of these original manuscripts, we formulated 6 recommendations for various aspects of bowel preparation in patients undergoing elective colorectal surgery.

Conclusion: Taking into account the lack of difference in postoperative infectious complication rates when MBP is omitted and the adverse effects of MBP, we believe that, based on the literature, MBP before surgery should be omitted.

Contexte : En dépit de données probantes indiquant que la préparation mécanique de l'intestin (PMI) ne réduit pas le taux de complications postopératoires, beaucoup de chirurgiens utilisent toujours la PMI avant l'intervention. Nous avons cherché à évaluer et résumer les données probantes disponibles sur la préparation préopératoire de l'intestin chez les patients qui subissent une chirurgie colorectale élective.

Méthodes : Nous avons effectué une recherche dans MEDLINE, EMBASE et les bases de données Cochrane pour repérer les essais contrôlés randomisés (ECR) où l'on a comparé les patients qui ont reçu une préparation de l'intestin à ceux qui n'en ont pas reçu. Deux auteurs ont analysé les résumés pour repérer les articles à soumettre à une évaluation critique. Nous avons utilisé les méthodes du Groupe de travail sur les services de prévention des États-Unis (United States Preventive Services Task Force pour évaluer la qualité de l'étude et le niveau des éléments probants, et pour formuler des recommandations finales. Les résultats évalués ont inclus les complications infectieuses postopératoires comme la déhiscence de l'anastomose et les infections superficielles du site chirurgical.

Résultats : Notre étude a permis de repérer 14 ECR et 8 méta-analyses. Compte tenu de la qualité et du contenu de ces manuscrits originaux, nous avons formulé 6 recommandations portant sur divers aspects de la préparation de l'intestin chez les patients qui subissent une chirurgie colorectale élective.

Conclusion : Comme il n'y avait pas de différence au niveau des taux de complications infectieuses postopératoires lorsque la PMI est omise et compte tenu des effets indésirables de la PMI, nous sommes d'avis, en nous basant sur les publications, qu'il faudrait abandonner la PMI avant les interventions chirurgicales.

Mechanical bowel preparation (MBP) before elective colorectal surgery has been the standard in surgical practice for over a century. It is believed that MBP decreases intraluminal fecal mass and presumably decreases bacterial load in the bowel. It has been argued that this

decrease in fecal load and bacterial contents reduces the rates of infectious postoperative complications, such as anastomotic dehiscence. These theories, however, have been based largely on clinical experience and expert opinion.[1,2] The first study to challenge the need for MBP was published in 1972.[3] Since then, there has been mounting level-I evidence indicating that MBP does not reduce the rate of postoperative complications, including anastomotic failure.[4–7]

Despite this evidence, a survey of colorectal surgeons in the United States published in 2003 revealed that 99% of the surgeons surveyed used MBP before surgery.[8] In 2006, a multinational audit of 1082 patients from 295 hospitals in Europe and the United States revealed that 86%–97% (mean 94%) of patients received preoperative MBP.[9] These surveys indicate that a large gap exists between the evidence surrounding the use of MBP and surgeon practices. It is unclear why surgeons have not changed practice to parallel the best evidence, since prescribing MBP also results in unnecessary costs (i.e., preadmission of patients, nursing care) as well as increased risks and discomfort for patients. Communication with local experts has indicated that the major hurdles may include lack of awareness of the evidence and, simply, reluctance to change.

Recommendations

1. There is good evidence for the omission of mechanical bowel preparation in the preoperative management of patients undergoing elective open right-sided colorectal surgery. **(Grade A recommendation)**
2. There is good evidence for the omission of mechanical bowel preparation in the preoperative management of patients undergoing elective open left-sided colorectal surgery. **(Grade A recommendation)**
3. There is insufficient evidence to support or refute the omission of mechanical bowel preparation in the preoperative management of patients undergoing elective low anterior resections with or without diverting ileostomy. **(Grade I recommendation)**
4. There is insufficient evidence to support or refute the omission of mechanical bowel preparation in the preoperative management of patients undergoing elective laparoscopic colorectal surgery. **(Grade I recommendation)**
5. There is fair evidence to recommend normal diet on the day prior to surgery in the preoperative management of patients undergoing elective colorectal surgery. **(Grade B recommendation)**
6. There is insufficient evidence to support or refute the use of enemas in the preoperative management of patients undergoing elective colorectal surgery. **(Grade I recommendation)**

There is some evidence that guidelines can be used as a knowledge translation strategy to target physician awareness.[10] This guideline has been prepared for general surgeons and general surgery residents who are involved in the preoperative management of patients undergoing elective colorectal surgery. The question addressed by this guideline is this: In patients undergoing elective colorectal surgery, do MBP, dietary modifications and enemas reduce the risk of infectious complications, such as superficial surgical site infections (SSIs) and anastomotic leaks?

Methods

Definitions

Bowel preparation before elective colorectal surgery can include a variety or combination of interventions. For the purposes of this guideline, MBP refers to the use of an oral laxative solution used to cleanse the colon of fecal contents (e.g., polyethylene glycol, sodium phosphate, sodium picosulphate, magnesium citrate). Preoperative dietary modifications and the use of enemas are also addressed as separate components of bowel preparation. The use of a normal diet refers to allowing patients a regular, unrestricted diet on the day before surgery. This can be replaced with a clear-fluid diet, which restricts patients from eating solid food. An enema is the administration of liquid in the rectum to evacuate stool.

Literature review

We performed 2 searches with the assistance of a medical librarian. The first search identified articles evaluating postoperative complications in patients who did and did not receive bowel preparation (including MBP, dietary restrictions and enemas). The second search identified articles describing adverse effects related to the use of MBP. These search strategies complete with medical subject headings are outlined in Table 1.

We searched MEDLINE, EMBASE and Cochrane databases to identify relevant articles published between January 1950 and February 2009 that compared adult patients who received bowel preparation or no bowel preparation and reported postoperative infectious complications as an outcome (search 1). The search was limited to randomized controlled trials (RCTs) involving adult human participants using the sensitivity strategy of Robinson and Dickersin.[11] We excluded nonrandomized controlled trials and studies including patients undergoing emergency colorectal surgery.

We also searched MEDLINE, EMBASE and Cochrane databases to identify relevant articles pertaining to adverse effects (search 2). The search strategy was not limited to publication type. We manually searched the reference lists of selected manuscripts from each literature search to

further identify relevant research studies. Two reviewers (C.E., S.S.F.) independently assessed all titles and abstracts to select the studies to be included in this guideline. Disagreement on selection was resolved by consensus.

Quality assessment

Quality appraisal was performed independently by 2 authors (C.E., S.S.F.). The selected manuscripts were reviewed and a quality assessment was performed using the criteria of the U.S. Preventive Services Task Force (USPSTF).[12] The RCTs received a good rating provided patients in the intervention and control groups were comparable at the start of the trial, there was no crossover between the 2 groups, minimum follow-up of 80% was reported, interventions were clearly defined, well-defined and reproducible outcome assessments were used equally in both groups, outcome assessors were blinded, intention-to-treat analysis was employed and appropriate attention was given to confounders in the analysis. Studies were deemed to be of poor quality if they had any one of the following: gross differences between the intervention and control groups at the start of the study, greater than 10% crossover between the 2 groups, substantial (> 20%) loss to follow-up, lack of a power calculation, or interventions that were not clearly defined. Studies with minor methodological flaws received a fair rating. Meta-analyses received a good rating if they were published within the last 3 years, included a comprehensive literature search, duplicated study selection and/or data extraction, used relevant selection criteria, provided characteristics of the included studies, documented and used a quality assessment to formulate conclusions, used statistical methods to combine study findings described (i.e., pooled analysis, tests for heterogeneity), assessed the likelihood of publication bias and stated conflicts of interest.

Recommendations

After critical appraisal of the methodology and evidence of the included studies, we made recommendations using the criteria established by the USPSTF.[12] Outcomes assessed included anastomotic dehiscence and superficial SSIs. These outcomes were reviewed for all patients undergoing elective colorectal surgery as well as for the following subgroups: patients undergoing low anterior resections with or without diverting ileostomies and patients undergoing laparoscopic colorectal surgery. Recommendations are also made regarding preoperative dietary modifications and the use of preoperative enemas. Finally, the Canadian Society of Colon and Rectal Surgeons endorsed this guideline.

Table 1. Search strategy for finding evidence regarding mechanical bowel preparation (MBP) in patients undergoing elective colorectal surgery

Search	MEDLINE/Cochrane	EMBASE
1: MBP and postoperative complications	1. (mechanical adj2 bowel adj2 prepar:).ti,ab. **OR** exp cathartics/ **OR** laxatives/ 2. exp Colorectal Neoplasms/ **OR** exp Colonic 3. Neoplasms/ **OR** exp Rectal Neoplasms/ 4. exp Colorectal Surgery/ or exp Surgery/ **OR** exp Colorectal Neoplasms/su or exp Colonic Diseases/su or exp Rectal Diseases/su or Anastomosis, Surgical/ or Colorectal Surgery 5. 1 **AND** 2 **AND** 3 6. Robinson & Dickersin Sensitivity Strategy 7. 4 **AND** 6	1. (Bowel adj5 Prepar:).mp. 2. exp Intestine Preparation/ **OR** exp Laxative/ 3. 1 **AND** 2 4. exp PELVIS SURGERY/ or exp MAJOR SURGERY/ or exp MINIMALLY INVASIVE SURGERY/ or exp LAPAROSCOPIC SURGERY/ or exp ANUS SURGERY/ or exp COLON SURGERY/ or exp INTESTINE SURGERY/ or exp GASTROINTESTINAL SURGERY/ or exp RECTUM SURGERY/ or exp COLORECTAL SURGERY/ or exp ABDOMINAL SURGERY/ or exp SURGERY/ or exp CANCER SURGERY/ or exp GENERAL SURGERY/ or exp ELECTIVE SURGERY/ 5. exp Intestine Tumor/ **OR** exp Large Intestine Disease/ 6. 3 **AND** 4 **AND** 5 7. exp Postoperative Complication 8. 6 **AND** 7 9. Robinson & Dickersin Sensitivity Strategy 10. 8 **AND** 9
2: MBP and adverse effects	1. (mechanical adj2 bowel adj2 prepar:).ti,ab. **OR** exp cathartics/ **OR** laxatives/ 2. exp Cathartics/ae [Adverse Effects] **OR** exp laxatives/ae 3. 1 **OR** 2 4. exp Colorectal Neoplasms/ **OR** exp Colonic Neoplasms/ **OR** exp Rectal Neoplasms/ 5. exp Colorectal Surgery/ or exp Surgery/ **OR** exp Colorectal Neoplasms/su or exp Colonic Diseases/su or exp Rectal Diseases/su or Anastomosis, Surgical/ or Colorectal Surgery/ 6. 4 **OR** 5 7. 3 **AND** 4 8. Robinson & Dickersin Sensitivity Strategy 9. 7 **AND** 8	1. (Bowel adj5 Prepar:).mp. 2. exp Intestine Preparation/ **OR** exp Laxative/ 3. 1 **AND** 2 4. exp Adverse Drug Reaction 5. 3 **AND** 4 6. exp Intestine Tumor/ **OR** exp Large Intestine Disease/ 7. 5 **AND** 6 8. Robinson & Dickersin Sensitivity Strategy 9. 7 **AND** 8

Table 2. Quality criteria for randomized controlled trials of mechanical bowel preparation (MBP) reporting postoperative complications as an outcome

Study	Quality rating	Comparable groups	Lack of contamination	Follow-up > 80%	Clearly defined interventions	Reliable measurements	Important outcomes considered	Blinded	Power	ITT	Confounders
Pena-Soria[24]	Good	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contant et al.[22]	Fair	No MBP group had more smokers and patients with IBD	Yes	Yes	Yes	Yes	Yes	No	No Needed 1400 patients and analyzed 1354, but CIs were narrow enough to exclude a relevant difference	Yes	Yes
Jung et al.[23]	Fair	Yes	No 2.4% crossover	Yes	Yes	Yes	Yes	No Not mentioned	No Underpowered to detect a 50% change in complication rate	Yes	No Different preparations used depending on site of surgery
Platell et al.[21]	Fair	Yes	Yes	Yes	Yes	Yes	Yes	No Not mentioned	No Underpowered to detect an equivalence in complication rate	Yes	Yes
Ram et al.[20]	Poor	Yes	Yes	Yes	Yes	Yes	Yes	No Not mentioned	No No power calculation	Yes	Yes
Bucher et al.[18]	Good	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zmora et al.[8]	Fair	Yes	Yes	Yes	Yes	Yes	Yes	No Not mentioned	No No power calculation	Yes	Yes
Fa-Si-Oen et al.[19]	Fair	Yes	Yes	Yes	Yes	Yes	Yes	No Follow-up was by blinded assessor but 1 outcome was unclear	No No power calculation	Yes	Yes
Young Tabusso et al.[17]	N/A										
Miettinen et al.[16]	Fair	Yes	Yes	Yes	Yes	Yes	Yes	No Not mentioned	No No power calculation	Yes	Yes
Fillmann et al.[15]	N/A										
Santos et al.[14]	Fair	Yes	Yes	Yes	Yes	Yes	Yes	No Not mentioned	No No power calculation	Yes	Yes
Burke et al.[5]	Fair	Yes	Yes	Yes	Yes	Yes	Yes	No Not mentioned	No Power calculation in conclusion but study underpowered	Yes	Yes
Brownson et al.[13]	N/A										

CIs = confidence intervals; IBD = irritable bowel disorder; ITT = intent to treat; N/A = not applicable.

RESULTS

Our search identified 14 unique RCTs.[4,5,13–24] One trial[15] was published twice and included only once. Another trial[24] was published as both an interim and final analysis; we included only the final analysis. Two trials published subgroup analyses as separate manuscripts and were excluded from further review to eliminate duplicate results.[4,19] A summary of our quality assessment of the RCTs is shown in Table 2. We did not assess the quality of 2 trials[15,17] because they were not published in English.

The literature review identified 8 meta-analyses.[6,25–31] These meta-analyses reported different combinations of the 14 published RCTs. The largest meta-analysis published in 2009 combined the results of the 14 RCTs.[31] The Cochrane review was published in 2003 and was updated in 2005.[26] We included the most current version. The Cochrane review was also published in another source separately by the same authors, and we excluded this duplicate publication. A summary of the quality assessment of these 8 meta-analyses is shown in Table 3.

Mechanical bowel preparation

Patients undergoing open elective colorectal surgery: anastomotic leaks

All 14 trials compared anastomotic leak rates in patients receiving MBP and those not receiving MBP. The results for anastomotic leak rates in these trials are summarized in Table 4. Two of the 14 trials found significant differences in anastomotic leak rates in favour of the omission of MBP.[13,17] The other 12 trials found no significant differences in the anastomotic leak rates. Two of these trials were large and are described in further detail below.[22,23] The main flaw in the other trials was that they were underpowered.

An RCT by Contant and colleagues[22] published in 2007 was a multicentre trial where investigators from 13 hospitals in the Netherlands randomly assigned 670 patients to receive MBP and 684 patients to no MBP. Those patients receiving MBP were prescribed either polyethylene glycol with bisacodyl or a sodium phosphate solution. There was no significant difference in anastomotic leaks (difference 0.6%, 95% confidence interval [CI] –1.7% to 2.9%, $p = 0.69$).[22] This was a fair-quality RCT with one of its strengths being its large sample size. However, like many of the RCTs performed on this topic, outcome assessment was not blinded. Furthermore, the 2 groups were not comparable at the beginning of the trial; there was a larger proportion of smokers and patients with inflammatory bowel disease in the MBP group.

In the next RCT by Jung and colleagues,[23] all Swedish centres and 1 German colorectal unit participated. In all, 686 patients were randomly assigned to receive MBP and 657 patients to no MBP;[23] 47% of patients in the MBP group were prescribed a polyethylene glycol preparation and 48.5% received a sodium phosphate preparation. There were no significant differences between the 2 groups for the primary outcomes of cardiovascular, general infectious and surgical-site complications. Specifically, anastomotic dehiscence was seen in 2.3% of patients in the MBP group and 2.6% of patients in the no MBP group. Six patients in each group died ($p = 0.94$).[23]

The authors examined the generalizability of the results and potential selection bias by comparing study participants to those patients who were not enrolled in the study at 3 participating centres. They found no statistically significant differences in the demographics or the outcomes between these 2 groups of patients. This study did not show a significant difference but was also underpowered in that it was powered to detect a 50% difference in complication rates. However, it is unlikely that the addition of

Table 3. Quality criteria for meta-analyses of mechanical bowel preparation (MBP) reporting postoperative complications as an outcome

Study	Quality rating	Recent	Comprehensive literature search	Duplicate selection or extraction	Relevant selection criteria	Characteristics of included studies	Quality assessment	Quality used to formulate conclusions	Pooled analysis	Publication bias	Conflicts of interest stated
Slim et al.[31]	Fair	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Pineda et al.[25]	Poor	Yes	Yes	No mention	Yes	Yes	No	No No assessment of quality	Yes	No mention	Yes
Muller-Stich et al.[29]	Poor	Yes	Yes	No mention	Yes	Yes	No	No No assessment of quality	Yes	No mention	No
Guenaga et al.[26]	Fair	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bucher et al.[27]	Fair	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Slim et al.[6]	Fair	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Wille-Jorgensen et al.[28]	Fair	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Platell and Hall[30]	Poor	No	No Literature search not described	No mention	Yes	Yes	Yes	Yes	Yes	No mention	No

57 patients (for a total of 1400 patients as required by the reported sample size calculation) would change the conclusion.[23] For these reasons, this was not deemed a fatal flaw and we gave the trial a fair rating.

Our review of the included meta-analyses revealed that 1 meta-analysis provided no pooled data and reported only a descriptive analysis of the included studies.[29] Of the remaining 7 meta-analyses, 4 reported statistically significant differences in the pooled results for anastomotic leakage.[26–29] Of these 4 meta-analyses showing a difference, the largest and most recent was the Cochrane review published in 2005.[26] Three of the 7 meta-analyses found no significant difference between the MBP and the no MBP groups.[25,30,31] Of the 3 meta-analyses that reported no difference in anastomotic leak rates, 1 was the oldest review,[30] including only 3 trials, and the other 2[25,31] were the most recent reviews.

The 2 most recent fair-quality meta-analyses were published by Guenaga and colleagues in 2005[26] as a Cochrane systematic review and by Slim and colleagues[31] in 2009. The fair-quality review by the former group was an update of the first Cochrane review published in 2003 and included 9 trials with a total of 1592 patients.[26] Of these patients, 789 were allocated to the MBP group and 803 to the no MBP group. The main outcome was anastomotic leakage; other outcomes evaluated included mortality, superficial SSIs, peritonitis and reoperation. The overall anastomotic leakage in both groups indicated that MBP was associated with a higher rate of anastomotic leakage (odds ratio [OR] 2.03, 95% CI 1.276–3.26, $p = 0.003$).[26] The authors of this review concluded that MBP for patients undergoing elective colorectal surgery has not proven valuable and the procedure should be omitted as it may increase the risk of anastomotic dehiscence. The primary strength of this meta-analysis was the thorough discussion of the quality and methodology of the included articles.

The meta-analysis published by Slim and colleagues[31] in 2009 included 14 trials with a total of 4859 patients and provided different results. This meta-analysis included substantially more patients because of the inclusion of the trials by Jung and colleagues[23] and Contant and colleagues,[22] which were published after the meta-analysis by Guenaga and colleagues.[26] This meta-analysis was given a fair quality rating because conflicts of interest were not reported. In all, 2452 patients were randomly assigned to the MBP group and 2407 to the no MBP group. The outcomes reported were rates of anastomotic leakage and superficial SSIs. The pooled results revealed no significant difference in anastomotic leakage rates between the 2 groups with a fairly narrow 95% CI (OR 1.12, 95% CI 0.824–1.532, $p = 0.46$).[31] Although these results differed from the results of the Cochrane review, these authors again concluded that there is no benefit to using MBP in patients undergoing elective colorectal surgery.[31]

Patients undergoing open elective colorectal surgery: SSIs

All 14 RCTs included superficial SSIs as another end point, and these results are summarized in Table 5. In all 14 trials, there were no significant differences in the rates of superficial SSIs in the MBP and no MBP groups.[4,5,13–24] One of the 7 meta-analyses reported a significant difference in superficial SSIs between the 2 groups, with an increased rate of superficial SSIs in patients who received MBP (difference 3.4%, 95% CI –1.6% to 8.4%, $p = 0.002$).[30] The other 6 meta-analyses found no difference in the rates of superficial SSIs when comparing patients who did and did not receive MBP.[6, 25–8] Guenaga and colleagues[26] reported rates of superficial SSIs as 7.4% (59/789)

Table 4. Summary of evidence for anastomotic leaks for the 14 randomized controlled trials

Study	No. patients	Anastomotic leaks, no. (%)		*p* value
		MBP	No MBP	
Brownson et al.[13]	134	8/67 (12.0)	1/67 (1.5)	0.030
Burke et al.[5]	169	3/82 (3.7)	4/87 (4.6)	0.91
Santos et al.[14]	149	7/72 (9.7)	4/77 (5.2)	0.29
Fillmann et al.[15]	60	2/30 (6.7)	1/30 (3.3)	1.00
Miettinen et al.[16]	267	5/138 (3.6)	3/129 (2.3)	0.72
Young Tabusso et al.[17]	47	5/24 (21.0)	0/23 (0)	0.050
Fa-Si-Oen et al.[19]	250	7/125 (5.6)	6/125 (4.8)	0.78
Zmora et al.[8]	380	7/187 (3.7)	4/193 (2.1)	0.33
Bucher et al.[18]	153	5/78 (6.4)	1/75 (1.3)	0.21
Ram et al.[20]	329	1/164 (0.6)	2/165 (1.2)	1.00
Platell et al.[21]	294	3/147 (2.0)	7/147 (4.8)	0.20
Contant et al.[22]	1354	32/670 (4.8)	37/684 (5.4)	0.60
Jung et al.[23]	1343	13/686 (1.9)	17/657 (2.6)	0.39
Pena-Soria et al.[24]	97	4/48 (8.3)	2/49 (4.1)	0.44

MBP = mechanical bowel preparation.

Table 5. Summary of evidence for superficial surgical site infections (SSIs) for the 14 randomized controlled trials

Study	No. patients	Superficial SSIs, no. (%)		*p* value
		MBP	No MBP	
Brownson et al.[13]	179	5/86 (5.8)	7/93 (7.5)	0.77
Burke et al.[5]	169	4/82 (4.9)	3/87 (3.5)	0.71
Santos et al.[14]	149	17/72 (24.0)	9/77 (12.0)	0.06
Fillmann et al.[15]	60	1/30 (3.3)	2/30 (6.7)	1.00
Miettinen et al.[16]	267	5/138 (4.0)	3/129 (2.0)	0.72
Young Tabusso et al.[17]	47	2/24 (8.3)	0/23 (0)	0.49
Fa-Si-Oen et al.[19]	250	9/125 (7.2)	7/125 (5.6)	0.61
Zmora et al.[8]	380	12/187 (6.4)	11/193 (5.7)	0.77
Bucher et al.[18]	153	10/78 (13.0)	3/75 (4.0)	0.07
Ram et al.[20]	329	16/164 (9.8)	10/165 (6.1)	0.21
Platell et al.[21]	294	19/147 (12.9)	21/147 (14.3)	0.73
Contant et al.[22]	1354	90/670 (13.4)	96/684 (14.0)	0.82
Jung et al.[23]	1343	54/686 (7.9)	42/657 (6.4)	0.29
Pena-Soria et al.[24]	97	6/48 (12.5)	6/49 (12.2)	0.97

MBP = mechanical bowel preparation.

in the MBP group and 5.4% (43/803) in the no MBP group (OR 1.46, 95% CI 0.97–2.18, $p = 0.07$). In the meta-analysis by Slim and colleagues,[31] the rate of superficial SSIs in the MBP group was 9.5% compared with 8.3% in the no MBP group (OR 1.17, 95% CI 0.96–1.44, $p = 0.11$).

Patients undergoing low anterior resections with or without diverting ileostomy

It has been well documented that the risk of anastomotic dehiscence is greater following low colorectal or coloanal anastomoses, and these low anastomoses have been associated with high rates of morbidity and mortality.[32] For this reason, many surgeons performing these operations opt to protect the anastomosis with a diverting stoma. The use or omission of MBP in patients undergoing low anterior resection (LAR) with or without diverting stoma in particular poses a difficult dilemma and raises important concerns. Surgeons may hesitate to omit MBP in these patients because it would leave a column of stool between the stoma and the anastomosis. In the event that such patients experience an anastomotic leak, there would still be a risk of fecal contamination despite the anastomosis having been protected. In patients who do not receive a diverting stoma, surgeons may also be concerned with the potentially increased morbidity associated with an anastomotic leak.

Patients undergoing an LAR with a diverting ileostomy were poorly represented in the 14 RCTs included in our review for 2 main reasons. Some RCTs (2 of 14) excluded patients who underwent LAR or LAR with anastomoses below the peritoneal reflection.[19,20] Others (5 of 14) excluded patients who had planned diverting stomas.[4,18,22–24] Finally, in some RCTs (3 of 14) the level of the anastomosis and whether the patients had diverting stomas was unclear.[13,15,17]

Five RCTs included patients undergoing LAR, and the results of 4 of them[4,5,14,16] were included in a subgroup analysis reported in the Cochrane review.[26] In one of these RCTs,[14] whether patients received diverting stomas was not mentioned. In another,[4] patients with diverting stomas were excluded, and the other 2 studies[5,16] clearly state that patients did not receive diverting stomas. When the results of this subgroup of LAR patients from these 4 RCTs were pooled in the Cochrane review, the rate of anastomotic leakage for LAR was 9.8% (11 of 112) in patients in the MBP group compared with 7.5% (9 of 119) in patients in the no MBP group.[26] The OR was 1.45 (95%CI 0.57–3.67, $p = 0.40$) and was not statistically significant, with wide 95% CIs, likely because of the small sample size.[26]

There is 1 RCT published by Platell and colleagues[21] that included a substantial proportion of patients having LAR with diverting stomas. This study was underpowered to show equivalence, although it did reveal statistically significant differences in some secondary outcomes. Therefore, we gave this study a fair rating. Patients were randomly assigned to receive oral MBP (polyethylene glycol) or a single phosphate enema only. For the purpose of this guideline, we considered the enema group to be the no MBP group because none of these patients received an oral MBP. In all, 147 patients were randomly assigned to MBP and 147 patients to no MBP.[21] Sixty-four percent (94 of 147) of patients in the MBP group and 55% (81 of 147) of patients in the no MBP group underwent an anterior resection.[21] Furthermore, 39% (57 of 147) of patients in the MBP group and 32% (47 of 147) of patients in the no MBP group had a diverting stoma. The authors stated that patients undergoing a low or ultra-low anterior resection were "routinely covered with a defunctioning loop ileostomy."[21] There were 3 anastomotic leaks in the MBP group and 7 in the no MBP group (2% and 4.8%, respectively, $p = 0.20$).[21] However, none of the patients in the MBP group compared with the 6 patients in the no MBP group required reoperation (0% and 4.1%, respectively, $p = 0.013$).[21] These results led to the trial being closed prematurely. The mortality rate in the MBP group was 2.7% compared with 0.7% in the no MBP group (OR 1.62, 95%CI 0.45–36.98, $p = 0.18$). There was no significant difference in the rate of superficial SSIs between the MBP and no MBP groups.[21]

These results are in contrast to those of all the other RCTs and meta-analyses. However, this trial differs in that patients in the no MBP group received an enema. To make further conclusions about the use of enemas in the preoperative preparation of patients undergoing elective colorectal surgery, an RCT examining only the enema intervention would be required. We included this trial in this guideline because many surgeons who disagree with the omission of MBP cite this article as an example of increased complications when no MBP is prescribed. However, as demonstrated above, it is important to distinguish this study from the others as it compares a different intervention in addition to comparing MBP versus no MBP.

Patients undergoing laparoscopic colorectal resections

Although there are no studies examining the effect of MBP in patients undergoing elective laparoscopic surgery, the evidence presented in this guideline likely can be extrapolated to this population. There is no clinical reason why patients having laparoscopic colorectal surgery would be more likely to develop postoperative infectious complications. Some argue that MBP may be required in patients with small tumours that may not be appreciated laparoscopically, thus requiring intraoperative colonoscopy, but preoperative tattooing of the lesion would obviate such a need. Some surgeons have also indicated that the unprepared colon may be slightly heavier and thus difficult to manipulate laparoscopically.

Adverse events associated with MBP

Our search strategy identified 1 RCT of fair quality that

examined the adverse histological effects of MBP. There were many other citations in the form of letters to the editor and case reports describing the adverse effects related to MBP. The RCT published by Bucher and colleagues[33] reported the histological changes in intestinal mucosa in 25 patients who had MBP with polyethylene glycol compared with 25 patients who did not receive MBP. There was a significant difference in the loss of superficial mucous

Table 6. Evidence from case reports reporting the adverse effects of mechanical bowel preparation (MBP)

Study	Study type	Type of preparation used	Outcome	Comments
Gray and Colwell[36]	Review	Polyethylene glycol	Spontaneous rupture of the esophagus	• 4 case reports: 3 patients survived after surgical intervention, 1 death
Frizelle and Colls[37]	Case reports: 3 patients	1: Sodium phosphate 2: Sodium picosulfate/ magnesium citrate 3: Sodium phosphate	Grand mal seizure activity, hyponatremia	• epilepsy has developed in 1 of 3 patients
Ayus et al.[38]	Case reports: 4 patients	Polyethylene glycol	1, 2: Hyponatremia 3, 4: Hypernatremia	1: Status epilepticus: complete recovery 2: Grand mal seizures: cardiac arrest, death 3: Metabolic alkalosis: respiratory arrest, death 4: Seizures, aspiration: cardiac arrest, death
Mackey et al.[39]	Letter to the editor	Sodium phosphate	4 cases of tonic–clonic seizures	• 4 patients with no history of seizure or electrolyte abnormalities • Attributed to electrolyte imbalance resulting in seizures
Hookey et al.[40]	Review: 20 publications describing adverse events in 29 patients	Sodium phosphate	Hypocalcemia, hypotension, hypernatremia, hypokalemia, renal failure, hypovolemia, hyperphosphatemia	• Many of these adverse events are attributed to inappropriate dosing, pre-existing renal impairment • 4 of 29 patients did not have any clear or probable predisposing factors (dose or relative contraindication)
Tan et al.[41]	Case reports: 6 patients	Sodium phosphate	1, 2: Delayed awakening from general anesthesia 3–6: Severe electrolyte abnormalities	1: Baseline chronic renal failure: developed hypocalcemia, hypokalemia, hypernatremia, hyperphosphatemia and eventually required long-term hemodialysis 2: Healthy: developed metabolic and respiratory acidosis with acute renal failure and completely recovered 3: Dehydration, breathlessness, complete recovery 4: Coma, complete recovery 5: Tonic–clonic seizures, death 6: Seizures, central pontine myelinosis, death
Ullah et al.[42]	Case report	Sodium phosphate	Severe hyperphosphatemia, acute pulmonary edema, cardiorespiratory arrest	• 55-year-old man with diabetes, hypertension and end-stage renal disease
ADRAC[43]	Case reports: 16 reports	Sodium picosulfate	Hyponatremia with seizures, hyponatremia/ hypokalemia with syncope, unconsciousness, metabolic acidosis	• 4 reports of syncope and dehydration without concomitant electrolyte abnormalities
Franga and Harris[44]	Case report	Polyethylene glycol	Pancreatitis	• 75-year-old woman with a history of hypertension, COPD, peripheral vascular disease and no prior history of pancreatitis • Progressed to develop pancreatic pseudocysts
Boivin and Kahn[45]	Case reports: 2 patients	Sodium phosphate	1: Hypocalcemia with severe tetany 2: Hypocalcemia with perioral numbness/tingling	1: Attributed to chronic renal failure 2: No history of renal disease; attributed to magnesium depletion
Oh et al.[46]	Case reports: 2 patients	1: Magnesium citrate 2: Sodium phopshate	1: Ischemic colitis: patchy submucosal hemorrhage and mucosal denudation 2: Ischemic colitis: friable mucosa, submucosal hemorrhage with ulceration	1: Took magnesium citrate in preparation for a screening sigmoidoscopy 2: Previously had 5 colonoscopies with polyethylene glycol or sodium phosphate preparations and had no adverse reactions
Vukasin et al.[47]	Case report	Sodium phosphate	Severe hyperphosphatemia and hypocalcemia with tetany	• Otherwise healthy patient, no renal failure • All laboratory values returned to normal by 2 weeks
ADRAC[48]	Case reports: 3 reports	Sodium phosphate	1: Hyperphosphatemia/hypocalcemia 2: Hypocalcaemia, hyponatremia and hypokalemia 3: Hyperphosphatemia, hypocalcaemia, paraesthesia, carpal spasm and QT prolongation	1: Followed by renal failure and death (90-year-old man with no history of renal failure) 2: Dehydration and subsequent death (70-year-old woman with no history of renal failure) 3: Required hemodialysis; patient had history of renal failure

ADRAC = Adverse Drug Reactions Advisory Committee; COPD = chronic obstructive pulmonary disease.

($p < 0.001$), loss of epithelial cells ($p < 0.01$), edema of the lamina propria ($p < 0.01$), lymphocyte infiltration ($p < 0.02$) and polymorphonuclear cell infiltration ($p < 0.02$) when the 2 groups were compared. These changes were all more frequent in those patients who had received MBP. Although it is unclear if these morphological changes are clinically relevant, they could potentially result in bacterial translocation and anastomotic disruption.[34,35]

We reviewed 13 other selected articles describing the adverse effects of MBP.[36–48] The details of these manuscripts can be seen in Table 6. In brief, these case reports revealed that many of the different types of MBP, such as sodium picosulfate, polyethylene glycol, sodium phosphate and magnesium citrate, were associated with adverse effects.[37–43,45,47,48] The primary adverse effects were related to electrolyte and volume disturbances in both healthy patients and patients with underlying cardiac or renal disease. Furthermore, these electrolyte disturbances led to seizures, syncope, coma and even death in some patients. Finally, there have also been reports of MBP-associated ischemic colitis, pancreatitis and esophageal perforation.[36,44,46]

Dietary modifications

None of the 14 RCTs included in this review performed a direct comparison of different dietary modifications before surgery. Table 7 describes the specific MBP, dietary modifications and enemas that were used in each group in each RCT. Nine of the 14 RCTs stipulated no dietary restrictions before surgery, and patients in the no MBP arm received a normal or low-residue diet on the day before surgery. Since most of these trials allowed patients in the no MBP arm to have a normal diet before surgery and these patients did not have increased postoperative infectious complications, it is likely safe to omit dietary modifications in the preoperative management of patients undergoing elective colorectal surgery.

Table 7. Description of interventions

Study	MBP intervention	No MBP intervention
Brownson et al.[13]	PEG	—
Burke et al.[5]	Sodium picosulphate, CitraFleet x 24 h	DAT
Santos et al.[14]	Mineral oil 3 times/d x 5 d, optimal dose_enema x 2 d, CitraFleet x 24 h	Low-residue diet x 24 h
Fillmann et al.[15]	Mannitol + orange juice	Orange juice
Miettinen et al.[16]	PEG, no solid food	DAT
Young Tabusso et al.[17]	Mannitol or PEG, CitraFleet x 48 h	CitraFleet x 48 h
Fa-Si-Oen et al.[19]	PEG	DAT until 10 h before surgery
Zmora et al.[8]	PEG, DAT, enema for rectal resections	DAT, enema for rectal resections
Bucher et al.[18]	PEG, DAT, enema for anterior resections	DAT, enema for anterior resections
Ram et al.[20]	Sodium phosphate, low-residue diet	Low-residue diet x 24 h
Platell et al.[21]	PEG, CitraFleet x 24 h	Enema, CitraFleet x 24 h
Contant et al.[22]	PEG or sodium phosphate, FF x 24 h	DAT
Jung et al.[23]	PEG, sodium phosphate or enema	DAT
Pena-Soria[24]	PEG + enemas, dietary restrictions x 24 h	DAT

DAT = diet as tolerated; FF = full-fluid diet; MBP = mechanical bowel preparation; PEG = percutaneous endoscopic gastrostomy.

Enemas

Again, none of the 14 RCTs included in this review performed a direct comparison of enema versus no enema before surgery. Three of the 14 RCTs prescribed enemas for left-sided or rectal resections in patients in the no MBP group.[4,18,21] Also, in 5 of the 14 RCTs, patients in the MBP group also had an enema.[4,5,18,23,24] Applying this evidence, it is difficult to draw conclusions and make recommendations regarding the use or omission of enemas in patients undergoing elective colorectal surgery.

DISCUSSION

Summary of the evidence

Most of the evidence supports the omission of MBP and reveals that MBP is not associated with an increased risk of anastomotic dehiscence. Furthermore, there appears to be no difference in other postoperative complications, such as superficial SSIs. Based on the population of patients in these trials, these results can be applied to patients undergoing elective, open right-sided and left-sided colorectal resections. Mechanical bowel preparation is generally safe, but it has been associated with serious complications in patients with existing cardiac and renal disease as well as previously healthy patients. Furthermore, most patients find MBP to be unpleasant. Thus, the use of MBP has not been shown to be beneficial, but rather has been shown to be associated with rare but serious adverse effects.

There is less evidence regarding patients undergoing LAR with or without a diverting ileostomy. After thorough assessment of the included RCTs, only 1 provided a comparison of MBP and no MBP in this specific population, and all others excluded this group of patients. This fair-quality RCT revealed that patients receiving MBP had lower rates of anastomotic dehiscence, but this was not statistically significant.[21] This study was designed to be an equivalence study but was ended early owing to the need for reoperations in patients who experienced a leak. However, all patients in the no MBP group received a phosphate enema, which might account for the differences seen between the 2 groups. Furthermore, the Cochrane review included a subgroup analysis of patients undergoing LAR and showed no statistically significant difference in anastomotic leak rates between the MBP and no MBP groups.[26]

Patients undergoing laparoscopic colorectal resections are not included in any of the RCTs discussed in this guideline. The results from the included RCTs where patients underwent open procedures, however, likely can be generalized to this patient population.

Recommendations

A synthesis of the level-I evidence reveals that there is good evidence supporting the omission of MBP in the preoperative management of patients undergoing elective right-sided and left-sided colorectal surgical resections (grade A recommendation). Examining the data specifically for patients undergoing LAR with or without diverting stomas has revealed that there is insufficient evidence to support or refute the omission of MBP in the preoperative management of these patients (grade I recommendation). There is no specific evidence regarding patients undergoing laparoscopic colorectal surgery. Therefore, there is insufficient evidence to support or refute the omission of MBP in the preoperative management of patients undergoing elective laparoscopic colorectal surgery (grade I recommendation).

Although there is some heterogeneity when evaluating dietary modifications before elective colorectal surgery, most RCTs allowed patients in the no MBP group to consume a regular diet until midnight on the day before surgery. These interventions have revealed that there is fair evidence to recommend normal diet until midnight the day before surgery in the preoperative management of patients undergoing elective colorectal surgery (grade B recommendation). Finally, there is insufficient evidence to support or refute the use of enemas in the preoperative management of patients undergoing elective colorectal surgery (grade I recommendation).

These recommendations are driven mostly by the 2 large RCTs[22,23] and the 3 recent meta-analyses.[25,26,31] Although the primary RCTs have not shown a statistically significant difference in postoperative complications when comparing the MBP and no MBP groups, the common flaw in these studies is inadequate sample size and power. The utility of the meta-analyses is directed at this particular problem. Furthermore, the reports surrounding adverse effects of MBP reveal that although complications are rare and more common in individuals with underlying cardiac and renal disease, these complications are extremely serious. Taking into account the lack of difference in postoperative infectious complication rates when MBP is omitted and the adverse effects of MBP, we believe that we are justified in making a strong recommendation based on the literature.

Competing interests: None declared.

Contributors: All authors helped design the study, review and article and approved its publication. Drs. Eskicioglu and Forbes acquired and analyzed the data. Dr. Eskicioglu wrote the article.

References

1. Nichols RL, Condon RE. Preoperative preparation of the colon. *Surg Gynecol Obstet* 1971;132:323-7.
2. Chung RS, Gurll NJ, Berglund EM. A controlled trial of whole gut lavage as method of bowel preparation for colonic operations. *Am J Surg* 1979;137:75-81.
3. Hughes ES. Asepsis in large bowel surgery. *Ann R Coll Surg Engl* 1972;51:347-56.
4. Zmora O, Mahajna A, Bar-Zakai B, et al. Colon and rectal surgery without mechanical bowel preparation: a randomized prospective trial. *Ann Surg* 2003;237:363-7.
5. Burke P, Mealy K, Gillen P, et al. Requirement for bowel preparation in colorectal surgery. *Br J Surg* 1994;81:907-10.
6. Slim K, Vicaut E, Panis Y, et al. Meta-analysis of randomized clinical trials of colorectal surgery with or without mechanical bowel preparation. *Br J Surg* 2004;91:1125-30.
7. Wille-Jorgensen P, Guenaga KF, Matos D, et al. Preoperative mechanical bowel cleansing or not? An updated meta-analysis. *Colorectal Dis* 2005;7:304-10.
8. Zmora O, Wexner SD, Hajjar L, et al. Trends in preparation for colorectal surgery: survey of the members of the American Society of Colon and Rectal Surgeons. *Am Surg* 2003;69:150-4.
9. Kehlet H, Buchler MW, Beart RW Jr, et al. Care after colonic operation — is it evidence based? Results from a multinational survey in Europe and the United States. *J Am Coll Surg* 2006;202:45-54.
10. Pathman DE, Konrad TR, Freed GL, et al. The awareness-to-adherence model of the steps to guideline compliance: the case of pediatric vaccine recommendations. *Med Care* 1996;34:873-89.
11. Robinson KA, Dickersin K. Development of a highly sensitive search strategy for the retrieval of reports of controlled trials using PubMed. *Int J Epidemiol* 2002;31:150-3.
12. Harris RP, Helfand M, Woolf SH, et al. Current methods of the US Preventive Services Task Force: a review of the process. *Am J Prev Med* 2001;20(3 Suppl):21-35.
13. Brownson P, Jenkins AS, Nott D, et al. Mechanical bowel preparation before colorectal surgery: results of a prospective randomized trial [abstract]. *Br J Surg* 1992;79:461-2.
14. Santos JCM Jr, Batista J, Sirimarco MT, et al. Prospective randomized trial of mechanical bowel preparation in patients undergoing elective colorectal surgery. *Br J Surg* 1994;81:1673-6.
15. Fillmann EEP, Fillmann HS, Fillmann LS. [Cirurgia colorretal eletiva sem preparo]. *Rev Brasil Coloproctol* 1995;15:70-1.
16. Miettinen RPJ, Laitinen ST, Makela JT, et al. Bowel preparation with oral polyethylene glycol electrolyte solution vs. no preparation in elective open colorectal surgery. *Dis Colon Rectum* 2000;43:669-77.
17. Young Tabusso F, Zapata JC, Espinoza FB, et al. [Mechanical preparation in elective colorectal surgery, a useful practice or need?] [Article in Spanish]. *Rev Gastroenterol Peru* 2002;22:152-8.
18. Bucher P, Gervaz P, Soravia C, et al. Randomized clinical trial of

mechanical bowel preparation versus no preparation before elective left-sided colorectal surgery. *Br J Surg* 2005;92:409-14.

19. Fa-Si-Oen P, Roumen R, Buitenweg J, et al. Mechanical bowel preparation or not? Outcome of a multicenter, randomized trial in elective open colon surgery. *Dis Colon Rectum* 2005;48:1509-16.

20. Ram E, Sherman Y, Weil R, et al. Is mechanical bowel preparation mandatory for elective colon surgery? A prospective randomized study. *Arch Surg* 2005;140:285-8.

21. Platell C, Barwood N, Makin G. Randomized clinical trial of bowel preparation with a single phosphate enema or polyethylene glycol. *Br J Surg* 2006;93:427-33.

22. Contant CM, Hop WCJ, van't Sant HP, et al. Mechanical bowel preparation for elective colorectal surgery: a multicentre randomized trial. *Lancet* 2007;370:2112-7.

23. Jung B, Pahlman L, Nystrom PO, et al. Multicentre randomized clinical trial of mechanical bowel preparation in elective colonic resection. *Br J Surg* 2007;94:689-95.

24. Pena-Soria MJ, Mayol JM, Anula R, et al. Single-blinded randomized trial of mechanical bowel preparation for colon surgery with primary intraperitoneal anastomosis. *J Gastrointest Surg* 2008;12:2103-9.

25. Pineda CE, Shelton AA, Hernandez-Boussard T, et al. Mechanical bowel preparation in intestinal surgery: a meta-analysis and review of the literature. *J Gastrointest Surg* 2008;12:2037-44.

26. Guenaga KF, Matos D, Castro AA, et al. Mechanical bowel preparation for elective colorectal surgery. *Cochrane Database Syst Rev* 2005;(1): CD001544.

27. Bucher P, Mermillod B, Gervaz P, et al. Mechanical bowel preparation for elective colorectal surgery. A meta-analysis. *Arch Surg* 2004;139: 1359-64.

28. Wille-Jorgensen P, Guenaga KF, Castro AA, et al. Clinical value of preoperative mechanical bowel cleansing in elective colorectal surgery: a systematic review. *Dis Colon Rectum* 2003;46:1013-20.

29. Muller-Stich BP, Choudhry A, Vetter G, et al. Preoperative bowel preparation: Surgical standard or past? *Dig Surg* 2006;23:375-80.

30. Platell C, Hall J. What is the role of mechanical bowel preparation in patients undergoing colorectal surgery. *Dis Colon Rectum* 1998;41:875-83.

31. Slim K, Vicaut E, Launay-Savary M, et al. Updated systematic review and meta-analysis of randomized clinical trials on the role of mechanical bowel preparation before colorectal surgery. *Ann Surg* 2009;249:203-9.

32. Rullier E, Laurent C, Garrelon JL, et al. Risk factors for anastomotic leakage after resection of rectal cancer. *Br J Surg* 1998;85:355-8.

33. Bucher P, Gervaz P, Egger J, et al. Morphologic alterations associated with mechanical bowel preparation before elective colorectal surgery: a randomized trial. *Dis Colon Rectum* 2006;49:109-12.

34. Berg RD. Bacterial translocation from the gastrointestinal tract. *Adv Exp Med Biol* 1999;473:11-30.

35. Ballantyne GH. The experimental basis of intestinal suturing. Effect of surgical technique, inflammation and infection on enteric wound healing. *Dis Colon Rectum* 1984;27:61-71.

36. Gray M, Colwell JC. Mechanical bowel preparation before elective colorectal surgery. *J Wound Ostomy Continence Nurs* 2005;32:360-4.

37. Frizelle FA, Colls BM. Hyponatremia and seizures after bowel preparation: report of three cases. *Dis Colon Rectum* 2005;48:393-6.

38. Ayus JC, Levine R, Arieff AI. Fatal dysnatraemia caused by elective colonoscopy. *BMJ* 2003;326:382-4.

39. Mackey AC, Shaffer D, Prizant R. Seizure associated with the use of visicol for colonoscopy. *N Engl J Med* 2002;346:2095.

40. Hookey LC, Depew WT, Vanner S. The safety profile of oral sodium phosphate for colonic cleansing before colonoscopy in adults. *Gastrointest Endosc* 2002;56:895-902.

41. Tan HL, Liew QY, Loo S, et al. Severe hyperphosphatemia and associated electrolyte and metabolic derangement following the administration of sodium phosphate for bowel preparation. *Anaesthesia* 2002; 57:478-83.

42. Ullah N, Yeh R, Ehrinpreis M. Fatal hyperphosphatemia from a phosphasoda bowel preparation. *J Clin Gastroenterol* 2002;34:457-8.

43. Adverse Drug Reactions Advosiry Committee. Electrolyte disturbances with sodium picosulfate bowel cleansing products. *Aust Advers Drug React Bull* 2002;21:1.

44. Franga DL, Harris JA. Polyethylene glycol-induced pancreatitis. *Gastrointest Endosc* 2000;52:789-91.

45. Boivin MA, Kahn SR. Symptomatic hypocalcemia from oral sodium phosphate: a report of two cases. *Am J Gastroenterol* 1998;93:2577-9.

46. Oh JK, Meiselman M, Lataif LE Jr. Ischemic colitis caused by oral hyperosmotic saline laxatives. *Gastrointest Endosc* 1997;45:319-22.

47. Vukasin P, Weston LA, Beart RW. Oral fleet phospho-soda laxative-induced hyperphosphatemia and hypocalcemic tetany in an adult: report of a case. *Dis Colon Rectum* 1997;40:497-9.

48. Adverse Drug Reactions Advosiry Committee. Electrolyte disturbances with oral phosphate bowel preparations. *Aust Advers Drug React Bull* 1997;16:2.