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Achieving the best bowel preparation for colonoscopy

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Abstract

Bowel preparation is a core issue in colonoscopy, as it is closely related to the quality of the procedure. Patients often find that bowel preparation is the most unpleasant part of the examination. It is widely accepted that the quality of cleansing must be excellent to facilitate detecting neoplastic lesions. In spite of its importance and potential implications, until recently, bowel preparation has not been the subject of much study. The most commonly used agents are high-volume polyethylene glycol (PEG) electrolyte solution and sodium phosphate. There has been some confusion, even in published meta-analyses, regarding which of the two agents provides better cleansing. It is clear now that both PEG and sodium phosphate are effective

when administered with proper timing. Consequently, the timing of administration is recognized as one of the central factors to the quality of cleansing. The bowel preparation agent should be administered, at least in part, a few hours in advance of the colonoscopy. Several low volume agents are available, and either new or modified schedules with PEG that usually improve tolerance. Certain adjuvants can also be used to reduce the volume of PEG, or to improve the efficacy of other agents. Other factors apart from the choice of agent can improve the quality of bowel cleansing. For instance, the effect of diet before colonoscopy has not been completely clarified, but an exclusively liquid diet is probably not required, and a low-fiber diet may be preferable because it improves patient satisfaction and the quality of the procedure. Some patients, such as diabetics and persons with heart or kidney disease, require modified procedures and certain precautions. Bowel preparation for pediatric patients is also reviewed here. In such cases, PEG remains the most commonly used agent. As detecting neoplasia is not the main objective with these patients, less intensive preparation may suffice. Special considerations must be made for patients with inflammatory bowel disease, including safety and diagnostic issues, so that the most adequate agent is chosen. Identifying neoplasia is one of the main objectives of colonoscopy with these patients, and the target lesions are often almost invisible with white light endoscopy. Therefore excellent quality preparation is required to find these lesions and to apply advanced methods such as chromoendoscopy. Bowel preparation for patients with lower gastrointestinal bleeding represents a challenge, and the strategies available are also reviewed here.

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Key words: Colonoscopy; Optimal preparation; Polyethylene glycol; Sodium phosphate; Special patients; Timing

Core tip: Bowel preparation for colonoscopy is a central issue related to the quality of the procedure. There are different agents for bowel preparation that can be administered with different schedules. We review the most commonly used agents, as well as new agents and combinations. Moreover, certain considerations should be taken into account for special populations in order to improve safety, efficacy and tolerance. Regimens for bowel preparation in special situations are discussed, such as for pediatric patients, patients with diabetes or inflammatory bowel disease, and in cases of heart or kidney failure or lower gastrointestinal bleeding.

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INTRODUCTION

Colonoscopy is the method of choice to evaluate colonic mucosa and the distal ileum, and plays an important role in diagnosis and treatment. Its successful implementation depends on many factors, but colon cleansing is a key factor^[1]. Proper cleaning is usually defined as one that allows the detection of colonic polyps 5 mm or larger^[2], though this concept does not consider the shape of the lesions, and it is well known that flat lesions are harder to detect. The cecal intubation rate and adenoma detection rate are two of the main quality endoscopic indices, both of which are directly related to the quality of preparation^[3]. Insufficient cleaning can result in lower detection rates of incipient and advanced adenomas, flat lesions, and flat adenomas^[3-6], a higher rate of canceled procedures with increased costs, lengthier procedures, and a higher risk of complications^[7]. Bowel preparation is one of the issues that negatively influence the willingness of patients to undergo colonoscopy screening^[8,9]. Adherence to preparation is a key factor for improving bowel preparation. However, it has limitations due to side effects and poor tolerance among patients to the taste, which are the main reasons for avoiding the procedure^[10]. At present, there is no consensus on the ideal method of bowel preparation. This review will analyze different methods of bowel preparation currently available, factors associated with the quality of cleansing, and preparation in special settings, including urgent colonoscopy for lower gastrointestinal bleeding.

WHAT IS THE BEST AGENT FOR BOWEL PREPARATION?

Information from meta-analyses regarding polyethylene glycol and sodium phosphate

The two most widely studied formulations are solutions based on polyethylene glycol (PEG) and sodium phosphate (NaP). PEG electrolyte solution (PEG-ELS) was introduced by Davis *et al.*^[11] in 1980 and consists of an isotonic oral, non-digestible and non-absorbable solution. Typically, 4 L of PEG-ELS is administered; the high volume and the unpleasant taste are among the major disadvantages of this solution. In the late 1980s, NaP was introduced as an alternative low-volume solution^[12]. NaP is a saline laxative administered in two doses of 45 mL diluted in 250 mL water each. Due to its mechanism of action, safety precautions should be taken with patients with a history of or risk of developing renal dysfunction^[13].

Many clinical studies have attempted to determine which of these preparations provides better results in terms of colon cleansing, adherence and safety. However, the results are controversial and multiple methodological problems limit the value of comparison. In order to synthesize and critically analyze this information, several meta-analyses of randomized clinical trials (RCTs) have been published, which we will review below.

Six meta-analyses were published between 1998 and 2012 that compared PEG and NaP for bowel preparation of adult patients for elective colonoscopy^[14-19] (Table 1). Three of these were developed exclusively to evaluate this relationship^[14,17,18], whereas the other three included comparisons of different schedules of the same agent, or the use of other agents. Meta-analyses have also been published comparing different formulations of PEG^[20] that are not considered here. The meta-analyses included between 8 and 104 RCTs. Five of the six meta-analyses found no significant difference in quality between PEG and NaP^[18]. The outcomes of these meta-analyses considered effectiveness in terms of colon cleansing, tolerance, compliance and security. The main results and characteristics of these studies are summarized.

Effectiveness

Three of the meta-analyses^[14,15,18] concluded that NaP is better than PEG in achieving satisfactory colon cleansing (excellent or good: defined as the presence of small volumes of clear liquid in the lumen: < 25%, allowing for viewing more than 90% of the surface)^[17]. One of the meta-analyses evaluated PEG and NaP in various presentations and concluded that NaP (in tablet form) was superior to other modalities^[18]. The other two studies found no statistically significant differences among preparations. However, in their latest meta-analysis, which included the

Table 1 Features of meta-analyses that compared polyethylene glycol to sodium phosphate

Ref.	Period of inclusion	Comparisons	Trials, <i>n</i> ¹	Patients, <i>n</i> ¹	Results
Hsu and Imperiale ^[14]	1980-1996	PEG vs NaP	8/8	1286/1286	NaP better than PEG: Better at cleansing Better at compliance Lower cost Safety: NaP = PEG
Tan <i>et al</i> ^[15]	1990-2005	PEG/NaP/sodium picosulfate	29/18	6459/3484	NaP better than PEG: Better at cleansing Better at compliance Safety: NaP = PEG
Belsey <i>et al</i> ^[16]	Until January 2006	PEG/NaP/Others	82/25	-/3748	Cleansing: PEG = NaP NaP better for tolerance Safety: PEG = NaP
Juluri <i>et al</i> ^[17]	1990-2008	PEG vs NaP	18/18	2792/2792	NaP better than PEG: Better at cleansing Better at compliance Safety: NaP = PEG
Juluri <i>et al</i> ^[18]	1990-2008	PEG vs NaP	71/71	10201/10201	Not statistically different NaP more likely to comply better
Belsey <i>et al</i> ^[19]	Until June 2010	PEG/NaP/others	104/31	-/4450	PEG = NaP PEG better than NaP in proximal colon No information about compliance

¹total/PEG vs NaP. PEG: Polyethylene glycol; NaP: Sodium phosphate.

largest number of studies, Belsey *et al*^[19] showed that PEG achieved better cleansing of the ascending colon [odds ratio (OR) = 2.36; 95% confidence interval (CI): 1.16-4.77; *P* = 0.012], which is very relevant for colon cancer screening. They also found that PEG is better when the preparations are fully administered the day before the procedure (OR = 1.78; 95%CI: 1.13-2.8; *P* = 0.006). Unfortunately, all the meta-analyses concluded that there is a wide heterogeneity among the studies included in their reviews, in relation to the small number of trials, poor information regarding randomization methods, route of administering the solution, time between completing preparation and beginning colonoscopy, indication and adherence to fiber-free diet before the procedure, and the lack of validated scales to define colonic cleansing. This last aspect is very important, because this assessment will be influenced by the subjectivity of endoscopists, leading to wide inter-observer variability that limits the validity of the results^[7,21].

Compliance

Five meta-analyses evaluating this topic concluded that patients who received NaP have higher rates of success than those receiving PEG^[14-18]. As noted above, PEG normally requires high volumes (4 L). It also has a disagreeable flavor that provokes intolerance. Both factors result in lower success rates. However, available information suggests that there is no statistically significant difference when PEG administered in split doses or smaller volumes is compared to NaP^[18].

Safety

In general, the studies in the meta-analyses excluded patients with comorbidities such as renal failure, recent myocardial infarction, cirrhosis with ascites, congestive heart

failure, acute inflammatory bowel disease, bowel obstruction, etc. With these exclusions, four meta-analyses suggest that there is no statistically significant difference in the profile of clinically significant adverse effects^[14-17]. PEG is associated with higher rates of nausea, vomiting and bloating, while NaP has higher incidence of dizziness and mild biochemical abnormalities (hypernatremia, hypocalcemia, hyperphosphatemia, hypokalemia), without clinically relevant impacts^[16]. Phosphate-containing solutions have the drawback of side effects and may cause electrolyte problems (hyperphosphatemia, hypocalcemia, hypokalemia, plasma hyperosmolality, hyponatremia and hypernatremia)^[22]. Therefore, their use is discouraged in patients with impaired renal function, dehydration, hypercalcemia or hypertension requiring drug inhibitors of angiotensin converting enzyme, as these patients have experienced phosphate nephropathy related to age, and the dose of the drug^[23-25]. Recent guidelines do not support the use of NaP^[1].

In summary, overall results from available studies do not indicate that either agent is better than the other, while sub-analyses show PEG to be somewhat better. Although NaP seems to be more tolerable than high-dose PEG, concerns about safety significantly limit the applicability of this agent.

ARE THERE ANY ADVANTAGES TO LOW-VOLUME SOLUTIONS?

Although high-volume PEG formulations are more effective and safer than other osmotic agents, the main disadvantage is the large volume (4 L) that patients are required to ingest and the salty taste due to sodium sulfate. To improve its tolerability, flavored PEG solutions have been

developed (with no sulphates), while low-volume PEG (2 L) has also come into use^[17,26].

In a randomized study, a low-volume PEG (2 L) preparation combined with bisacodyl was similar to a standard full-volume PEG preparation in terms of efficacy, but was better tolerated^[27]. Five RCTs (a total of 1997 patients) used a commercially available formulation of 2 L of PEG with ascorbate (PEG-A) instead of the conventional 4-L dose of PEG^[28-32]. No significant differences were found between the low-volume and the 4-L formulations in terms of cleanliness for the entire colon. However, cleanliness in the right colon (assessed in a single study) was less often satisfactory with the 2-L than with the 4-L PEG (54% *vs* 82% of patients, $P < 0.001$)^[30]. Of note, cleanliness in the right colon can be particularly important in screening. Two RCTs reported that willingness to repeat bowel preparation was higher with the low-volume formulation than with the 4-L PEG (73% *vs* 65%, $P = 0.079$)^[29,30]. In another randomized study comparing PEG-A to 4-L PEG plus simethicone, no differences were observed in efficacy, safety or tolerance^[33]. In a RCT that compared PEG-A to another new low-volume solution (PEG-citrate-simethicone), both in combination with bisacodyl^[34], the latter preparation was more effective in bowel cleansing for outpatient colonoscopy. The two low volume solutions were similar in terms of levels of tolerability, safety, acceptability and compliance. However, in this study, the agents were administered on the day before the colonoscopy, which does not comply with current recommendations^[1].

PEG-A has also been compared to NaP solutions. In a randomized study, adequate cleansing was obtained in 63.9% with NaP solution *vs* 72.5% with PEG-A^[35]. Tolerance was higher with PEG-A. PEG-A has a high level of ascorbic acid (approximately 250 times the recommended daily allowance), which potentially causes hydroelectrolytic-metabolic disturbances. Nevertheless, a recent study showed that PEG-A is similar to 4 L of PEG in terms of safety and hydroelectrolytic changes, except for blood bicarbonate levels, which were lower with PEG-A, though within safe limits^[36].

Both magnesium citrate and sodium picosulfate (MC-SP) are also low-volume solutions that should be administered with sufficient liquid to prevent side effects. A combination of SP magnesium oxide and citric acid is commercially available. It can effectively clean the bowel in 70%-80% of patients, but may be associated with dehydration and electrolyte problems^[26]. As magnesium is removed exclusively by the kidneys, caution should be exercised in patients with renal failure. Several randomized trials comparing MC-SP preparations with an aqueous NaP preparation found that the SP-based preparations were better tolerated and produced a similar degree of cleansing^[37-39]. One trial in which the preparation agents were administered the day before colonoscopy found that right colon cleansing was better with MC-SP plus bisacodyl than with NaP and MC-SP alone^[40]. This study suggests that bisacodyl should be added if osmotic solutions

are to be given the day before.

MC-SP and PEG preparations have also been compared. One trial found that day-before dosing of MC-SP and a PEG preparation were similar regarding bowel cleansing, but the former was better tolerated by patients^[41]. A recent meta-analysis that includes most of the RCTs described showed that 4-L split-dose PEG is better than other bowel preparation methods for colonoscopy^[42]. In a related study that compared split dosing of MC-SP with day-before dosing of a PEG plus bisacodyl preparation, patients receiving the SP-based preparation had better colon cleansing and reported better tolerance of the preparation^[41,43].

Administering enemas, bisacodyl, or metoclopramide in addition to the standard dose of PEG has not been shown to improve the quality of the preparation or the patient's tolerance, so it is not recommended^[44,45]. However, bisacodyl does improve the effectiveness of the preparations of low-volume PEG (2 L)^[46].

An alternative to NaP is sodium sulfate. There are still very few studies evaluating this new preparation. A study comparing 4-L PEG solution (given on the day before) to sodium sulfate (given in two doses, the second on the day of the colonoscopy)^[22] observed better preparation with the latter (adequate: 71.4% *vs* 34.3%; $P < 0.001$) with no difference in adverse effects. In a pilot study of a Japanese population, sodium sulfate was effective in cleansing the colon in 98% of the cases^[47]. Comparison studies including low-volume solutions are shown in Table 2.

A KEY FACTOR FOR OPTIMAL PREPARATION: TIMING OF ADMINISTRATION

The timing of bowel preparation is among the major factors related to the quality of cleansing. However, this has been recognized only recently. In Japan, bowel preparation has consistently been administered on the same day as the colonoscopy^[48], usually only a few hours in advance, and often in the endoscopy unit. In contrast, Western countries have not introduced this concept until recently. In 1997, Frommer^[49] was the first author to argue that NaP achieved a better quality of cleansing when administered on the same day, and in 1998, Church^[50] argued the same regarding PEG. The argument is that gastric and intestinal secretions from the small to the large bowel continue, so that with time, the benefits of bowel cleansing are undone.

In a meta-analysis of randomized trials comparing a full dose of PEG (on the day before colonoscopy) with a split dose (second dose on the same day), Kilgore *et al*^[20] found that a split dose significantly increased the rate of satisfactory preparation, the willingness to repeat the same preparation, and significantly decreased the number of discontinued preparations and incidences of nausea. It is not unexpected that when bowel prep is administered the day before colonoscopy, the quality of cleansing

Table 2 Comparison studies including low-volume solutions

Ref.	Comparison	n	Conclusion
DiPalma <i>et al</i> ^[27] Jansen <i>et al</i> ^[28]	PEG 4 L <i>vs</i> PEG 2 L + 20 mg bisacodyl PEG 4 L	93/93 91/91/102/86/91	PEG 2 L + bisacodyl is more tolerable PEG 2 L + ascorbate equal to PEG 4 L solution in cleansing quality, taste and compliance NaP inferior to PEG 4 L in bowel cleansing quality
	<i>vs</i> PEG 4 L + with 20 mL simethicone <i>vs</i> PEG 2 L + ascorbate <i>vs</i> PEG 2 L + ascorbate with 20 mL simethicone <i>vs</i> NaP		
Pontone <i>et al</i> ^[29] Corporaal <i>et al</i> ^[30] Marmo <i>et al</i> ^[31]	PEG 4 L <i>vs</i> PEG 2 L + ascorbate PEG 4 L <i>vs</i> PEG 2 L + ascorbate PEG 4 L <i>vs</i> PEG 2 L + ascorbate	72/72 149/158 435/433	Residual stool score significantly lower with PEG 4 L PEG + ascorbate less effective in right colon cleansing PEG + ascorbate as effective as high-volume PEG-electrolyte solution but has superior palatability
Ell <i>et al</i> ^[32] Gentile <i>et al</i> ^[33] Repici <i>et al</i> ^[34]	PEG 4 L <i>vs</i> PEG 2 L + ascorbate PEG 4 L <i>vs</i> PEG 2 L + ascorbate PEG 2 L + ascorbate <i>vs</i> PEG 2 L + citrate + bisacodyl	153/155 60/60 202/203	PEG + ascorbate same efficacy and safety, better tolerance Similar efficacy PEG 2 L + citrate + bisacodyl more effective for bowel cleansing
Bitoun <i>et al</i> ^[35]	PEG 2 L + ascorbate <i>vs</i> NaP	169/171	PEG + ascorbate at least as efficacious as NaP, comparable efficacy, better tolerability profile
Rex <i>et al</i> ^[22] Renaut <i>et al</i> ^[37] Choi <i>et al</i> ^[38] Schmidt <i>et al</i> ^[39] Hookey <i>et al</i> ^[40]	4 L PEG SF-ELS <i>vs</i> NaP MC-SP <i>vs</i> NaP NaP <i>vs</i> magnesium citrate + NaP (45 mL) MC-SP <i>vs</i> NaP MC-SP + bisacodyl <i>vs</i> MC-SP <i>vs</i> NaP	68/68 32/41 79/80 182/190 105/109/101	NaP superior bowel cleansing, similar tolerability MC-SP better tolerated, similar cleansing effectiveness Both similar effectiveness MC-SP better tolerance, similar cleansing effectiveness MC-SP + bisacodyl better colon cleansing in the right colon compared with two other groups
Tjandra <i>et al</i> ^[42] Katz <i>et al</i> ^[41] Rex <i>et al</i> ^[43]	MC-SP <i>vs</i> NaP MC-SP <i>vs</i> PEG 2 L + 10 mg bisacodyl tablets PEG 2 L + bisacodyl 5 mg <i>vs</i> picosulphate	120/102 300/303 304/297	NaP better cleansing Similar quality of cleansing Picosulphate is better for cleansing bowel and tolerated

MC-SP: Magnesium citrate and sodium picosulfate; NaP: Sodium phosphate; PEG: Polyethylene glycol; SF-ELS: Sulfate-free electrolyte; SPS: Sodium picosulphate.

is poorer on the right side of the colon^[5]. There has been some confusion regarding the relationship between the timing of colonoscopy and the quality of bowel cleansing. Some reports have found that afternoon colonoscopies had superior quality cleansing, but this happened when bowel prep was given on the previous day for morning colonoscopies, and on the same day for afternoon colonoscopies; therefore, in the former, the preparation-colonoscopy interval was longer. For instance, Sanaka *et al*^[51] found inadequate bowel preparations in 15% of morning colonoscopies compared to 20% in afternoon colonoscopies when the patients received the preparation the day before. In a study that randomized patients for afternoon colonoscopies to receive 3.8 L of PEG administered the day before, or on the morning of the colonoscopy, the Ottawa score per segments and overall was significantly better with the latter group^[52]. Moreover, when the time interval from the moment of administration of the bowel prep to the colonoscopy remains stable, the quality of bowel prep is similar for morning or afternoon examinations. Eun *et al*^[53] compared 4-L PEG administered at 5 am for morning colonoscopies, or at 8 pm for afternoon examinations and found similar results in terms of quality of cleansing, noting that colonoscopies performed within 7 h of initiation of PEG intake and those performed within 4 h of completing PEG intake had better quality bowel cleansing. This time interval is accepted as adequate for same-day preparation. When the patients have been prepared the day before, the time interval is

different. One study used an intensive preparation strategy (4-L PEG plus a regular dose of NaP), with a median time interval from the last dose of the preparation agent to the start of colonoscopy of 13.5 h^[54]. In this study, only 14% of examinations had excellent quality cleansing and 38% good quality. Beyond 14 h after the last dose of the agent, there were no patients with good or excellent cleansing. Therefore, as Eun *et al*^[53] pointed out in their paper, the timing of bowel preparation, rather than that of the colonoscopy, determines the quality of cleansing.

One study gave an “intensive” bowel preparation schedule (low fiber diet for 3 d, liquid diet the day before, 10 mg bisacodyl, 3 L of split PEG) to patients with poor cleansing previously (most of the cases with preparation given the day before)^[55]. With this split regimen, adequate preparation was achieved in over 90% of the patients. Although there was no control group, this study suggests the importance of preparation timing on the quality of cleansing.

There may be some misunderstanding regarding the right timing for bowel preparation. It is often heard that split-doses should be the rule. However, more importantly than split-doses, we should keep in mind the concept of “same day” preparation, regardless of whether the agent is administered partly or wholly on the same day, and consider that at least half of the preparation should be administered on the same day, a few hours before the colonoscopy^[56]. A study compared the quality of cleansing with patient tolerance of 2 L of PEG-ELS, ad-

ministered either on the same day or in a split dose fashion^[56,57]. There was no difference in quality (with adequate bowel prep in > 90% patients in both groups). However, patients prepared on the same day only had significantly lower incidence of abdominal pain, slept better, and experienced less interference with their workday the day before.

Several concerns may dissuade doctors from recommending same-day preparation to their patients; first, the relatively short interval (2-5 h) recommended after ingesting prep agent can result in a risk of aspiration. However, there is empirical evidence against this from the Japanese experience^[48]. Moreover, Huffman *et al.*^[58] compared the gastric content of patients receiving only an upper endoscopy, and those undergoing both an upper and lower endoscopy, who received the bowel preparation either on the day before or on the same day. The mean gastric content was slightly reduced in patients undergoing only an upper examination (14.6 mL), but there was no difference in patients that had drunk the bowel prep, regardless of when it was administered (split or on the previous day), and the mean volume was approximately 20 mL.

Although the guidelines of the American College of Gastroenterology recommend split-bowel or same-day preparation for anyone undergoing screening colonoscopy, this may not be the common practice^[1,56]. A survey in 2010 (unpublished data) on bowel preparation practices in Spain found that only 15% of the centers gave the preparation, at least in part, on the same day for morning outpatient colonoscopies, whereas 81% of the centers gave the preparation on the same day for afternoon colonoscopies. Physicians often assume that their patients would not be willing to follow a recommendation of split doses^[59]. Nevertheless, in a survey study in the US, when patients were explained the importance of the same-day schedule, over 85% were willing to wake up during the night to drink the second dose of a split preparation, and 78% of those who had early morning appointments actually did so^[60].

There is abundant evidence indicating that bowel preparation should be administered at least in part on the same day as the examination, in relation to effectiveness of bowel cleansing and detection of neoplasms. Therefore, strategies to improve tolerance and adherence to this schedule should be sought, but patients (and physicians) should receive information about the importance of complying with the instructions for such preparation. However, in spite of the strong evidence available, it is still possible that a patient rejects drinking the preparation on the same day. There is no study specially designed to help provide an adequate preparation for patients receiving the agent on the day before the colonoscopy. There are several factors that could facilitate a better preparation quality in that situation. First, the study by Siddiqui *et al.*^[54] showed that when the interval between the preparation and the start of colonoscopy exceeds 13 h, the quality of cleansing becomes worse. Therefore, the interval should be reduced as much as possible, and should never be longer than 13 h. Secondly, as will be

explained later in this article, a low-fiber preparation on the day before the colonoscopy is more patient friendly. Moreover, when patients received a full dose of PEG on the day before the colonoscopy, the quality of cleansing in those who had a fiber free diet the day before was significantly better than in those patients who had a liquid diet^[61]. Therefore, a well-designed low-fiber diet should be recommended. Third, in patients who received preparation with MC-SP on the day before the colonoscopy, adding 10 mg bisacodyl two days before the colonoscopy significantly improved the quality of cleansing in the right colon^[40]. This adjuvant should probably be employed when bowel preparation cannot be given on the same day as the colonoscopy. Fourth, adding 4 mg loperamide after gut lavage (after liquid stools ceased) in patients who had received the preparation agent on the day before, achieved a significantly better cleansing in the cecum in most of the cases (mean interval from the preparation to colonoscopy around 13 h) in a randomized study. This idea is original and provocative and should be considered as an option, though the results should be confirmed in future studies^[62].

TO EAT, OR NOT TO EAT: FACTS ABOUT DIET AND QUALITY OF CLEANSING

Although the type of diet prior to colonoscopy may affect the quality of cleansing, there are surprisingly few studies on this question. Practices vary from no specific pre-exam diet in some Japanese units to liquids-only the day before, which is a common practice in the United States. An observational study with inpatients found that the only dietary modification that improved the quality of preparation was a liquids-only diet^[63]. Two randomized studies compared the usefulness of a well-defined low-fiber diet to that of a liquid diet the day before colonoscopy. In a Korean study, patients were randomized to a clear liquid diet or a commercial pre-packaged low-fiber diet that includes meals for breakfast, lunch and dinner^[64]. Patients received 4 L of PEG in the morning a few hours before colonoscopy. The PEG completion rate was similar in both groups, but satisfaction with bowel preparation was significantly higher with the low-fiber diet. There was no difference regarding adverse events. Moreover, quality of cleansing (Ottawa score) was better in the transverse colon in this group. Another study compared 4 L of PEG the day before with either a liquid or fiber-free diet (which was clearly specified for the different meals) the day before^[61]. Interestingly, in this study, the quality of cleansing was better in the fiber-free-diet group, probably because the patients could drink a significantly greater volume of PEG. Moreover, nausea, headaches and vomiting were significantly more common among the liquid-diet group. Another study randomized 230 outpatients receiving a preparation with a low-volume sulfate solution in a split dose, to follow a liquid diet

or a low-residue diet of specified foods the day before colonoscopy^[65]. Interestingly, the diet for each meal could be chosen from three options: easy-to-prepare, healthy, or restaurant. There was no difference in the quality of cleansing, but bowel preparation, satisfaction with diet and overall satisfaction were significantly higher with the low-fiber diet. Moreover, the rate of procedure cancellation was higher with the clear-liquid-diet group.

In a descriptive study including patients with poor quality cleansing, an intensive schedule was applied for the repeat colonoscopy, including a liquid diet the day before colonoscopy (and most importantly, with a split dose). The schedule worked well with 90% of patients having adequate cleansing^[55]. Therefore, while a well-defined low-fiber diet is generally adequate for outpatient colonoscopy, in certain situations with a high risk of inadequate cleansing, a liquid diet would be more appropriate. More studies in this field are needed.

WILL A MORE INFORMED PATIENT HAVE A BETTER-PREPARED COLON?

Instructions to patients for bowel preparation vary from one endoscopy unit to another and may feature only text (with more or less complex description of the preparation schedule) or include images or figures, with content that may include the importance of colonoscopy in colon cancer prevention, the importance of adequate colon cleansing, dietary recommendations for bowel preparation, and instructions on preparing and drinking cleansing agents. The type and amount of information and the way in which it is delivered to the patient can influence the quality of cleansing. A study in the United Kingdom found that comprehension of a written colonoscopy preparation leaflet was generally low among over 700 patients from different sociodemographic backgrounds, and that health literacy was an independent predictor of comprehension^[66]. Ness *et al*^[67] found that not following the preparation instructions was, as could be expected, an independent predictive factor for inadequate preparation (OR = 2.61; 95%CI: 1.52-4.75). There was some association with this factor and others associated with inadequate preparation, such as a history of stroke or dementia. Spiegel *et al*^[68] meticulously prepared an educational booklet (including images), designed after identifying barriers to colonoscopy preparation. Their patients were randomized to receive standard information or the booklet, and received bowel preparation the day before colonoscopy. Patients that received the booklet had a higher percentage of adequate bowel preparation (68% *vs* 46%; *P* = 0.054). In another study, patients that received bowel preparation in a split-dose system were randomized to receive regular written instructions or additional visual aids^[69]. The latter group had better bowel preparation. The importance of providing adequate information to the patients about colonoscopy, bowel preparation, and the importance of following the recommended schedule cannot be overstated.

Bowel preparation is less effective in hospitalized patients. In one randomized study, inpatients received standardized written instructions before colonoscopy, and one group additionally received a 5-min counseling session, explaining the importance of an adequate preparation. This intervention achieved significantly better bowel cleanliness scores^[70].

ARE THERE ALTERNATIVE METHODS TO DRINKING AN AGENT TO ACHIEVE GOOD PREPARATION?

The only accepted method for bowel preparation is antegrade ingestion of the agent, and in cases of poor tolerance or impossibility to willingly drink the agent (unconsciousness, dementia, encephalopathy), this antegrade administration can be provided by means of a nasogastric tube. Exclusive preparation with enemas is not accepted as a method of preparation for total colonoscopy, both for efficacy and safety reasons related to risk of explosion if electrocautery is applied^[71]. Poor palatability leading to nausea or vomiting can impact patient tolerance and eventually the quality of cleansing^[16].

Retrograde bowel cleansing is a promising method for patients with low tolerance or other problems with antegrade cleaning. Until recently, there had few descriptions, however, studies are starting to appear on this issue, probably because of recognition of the importance of colonoscopy for colorectal cancer screening and of bowel preparation for quality colonoscopy. In 1991, Chang *et al*^[72] reported a small randomized trial comparing oral PEG (4 L) administered on the previous day to retrograde per-rectal pulsed irrigation with warm tap water by means of a pump. The latter group of patients also received magnesium citrate to facilitate the cleansing of the right colon. There was no significant difference in cleansing quality or other variables of the colonoscopic procedure (time to cecum, aspirated volume, polyp detection).

In 2006, a new device, which consisted of a catheter connected to a pump and water jet, was tested in an animal study. It effectively and safely cleared unprepared animal colons in an average of 12 min^[73]. In 2010, another new device was assessed in a relatively large study (57 colonoscopies) with a porcine model^[74]. The device consisted of a pump connected to a valve for suction and a disposable part including a tube and a head to the endoscope. The device achieved adequate cleansing in a mean of 4 min. Two studies published in 2012 used the same new catheter-based device to clean the colons of patients with insufficient cleansing at colonoscopy^[75,76]. In a comparative study using sequential allocation, Eliakim *et al*^[75] applied either the new method or conventional washing with a 50 mL syringe when at least one colonic segment was poorly prepared. The overall colon and cecum-ascending improvement in cleanliness was significantly greater with the new device, while the procedural time was similar. With a device similar in design, Rigaux

et al.^[76] found better overall and cecum-ascending colon cleansing. Neither study reported on the timing for oral bowel preparation (in the first study, preparation was given the day before, personal communication), but the fact that there was a benefit on the right side of the colon could mean that this segment was especially hard to clean (therefore suggesting that the patients had been prepared the day before). The same year Kiesslich *et al.*^[77] reported the use of another new device based on a CO₂ pump and a catheter with which CO₂ and saline droplets are applied. In an application with 32 patients, the degree of cleanliness was significantly better, and its use was considered safe.

Horiuchi *et al.*^[78] applied a 500-mL PEG enema in the hepatic flexure through the working channel of the colonoscope in patients with poor preparation at colonoscopy. Patients were then allowed to go to the lavatory, and needed a mean of 52 min to complete bowel evacuation. Colonoscopy was then repeated, and adequate bowel cleansing was confirmed for 96% of the patients.

Finally, a retrospective study reported the results of another new device for retrograde cleansing. In this study, an evacuation device is inserted in the anus and secured and a sleeve is progressed deep into the colon^[79]. Warm water passed by gravity with the water container 2 m above the patient, and by a manual pump. Among the 125 patients who participated in this study, excellent or good quality cleansing was achieved in 89%. Only one patient required sedation during the cleansing procedure because of anxiety, and there were no complications. Fujii^[80] recently described a different approach to improve tolerance to bowel preparation by using an antegrade method without the need for patients to drink an agent. Patients who had to undergo upper and lower endoscopy in the same session were included. The proposed method consisted of infusing 1000 mL of PEG-ELS in the second portion of the duodenum (after having completed the diagnostic procedure) with a 50 mL syringe, and then an additional 200-500 mL in the stomach. After completing the upper endoscopy, patients could go to the toilet to complete bowel evacuation, and when the bowel effluent was clean, as confirmed by a nurse, patients underwent colonoscopy. Among the 152 patients who received this preparation method, the quality of bowel cleansing was adequate for 97%, with a mean total time for upper endoscopy of 14 min. There were no complications, and global patient satisfaction with the preparation was excellent for 85% of patients, and moderately satisfactory for 9%. If these results are confirmed in other study populations, this method could be considered for patients with poor tolerance/compliance to standard oral preparations.

HOW TO ACHIEVE THE BEST BOWEL PREPARATION IN SPECIAL SITUATIONS

Inflammatory bowel disease

Complete and good quality mucosal visualization by colonoscopy with intubation of the ileum along with

segmental mucosal biopsies is the most valuable tool to distinguish different types of inflammatory bowel disease (IBD), to differentiate IBD from other intestinal disorders, and to determining prognosis and the appropriateness of therapies, along with diagnosis and treatment of complications^[81-87].

There have not been adequate studies to determine the best ways to prepare IBD patients for colonoscopy and to identify safety issues associated with different approaches. The lack of research in bowel preparation under inflammatory conditions is therefore surprising, especially for patients who need bowel preparation for repeated examinations^[88]. Some publications have found that IBD patients reported low satisfaction from the bowel preparation compared to other patients^[89]. Moreover, some ulcerative colitis patients have reported flare symptoms after colonoscopy^[90]. The reasons for these negative experiences are unknown, but bowel preparation could be a contributing factor. Clinicians should recognize these side effects of colonoscopy in patients with IBD. The indications of how to prepare these patients prior to colonoscopic procedures are based mostly on expert opinions.

Alternatives for bowel preparation in IBD: Options for bowel preparation include oral PEG-based lavage and oral or enema phosphate. Given that oral NaP solution is associated with frequent aphthoid-like mucosal lesions with missing interpretations, oral PEG is the preferred solution for bowel cleansing^[91,92].

The suggested volume of oral PEG is variable, ranging from 2 L to 4 L or more, 6-24 h before the procedure, until reaching the evacuation of a clear fluid^[92]. There are no clear recommendations regarding the volume of PEG in the presence of high-volume diarrhea or a high number of bowel movements. However, it seems reasonable to reduce the volume of oral PEG, use a phosphate enema or a combination of both with these patients.

Active IBD setting: In patients with suspected IBD and mildly or moderately active disease, a full colonoscopy along with segmental mucosal biopsies must be performed with formal bowel preparation, preferably using oral PEG. Good bowel cleansing is important in most cases for direct inspection of mucosal patterns of the colon and distal terminal ileum, along with an accurate delineation of the affected location^[82,88,93,94].

Severely active IBD: Although colonoscopy appears to be more cost effective than index sigmoidoscopy^[95,96], a full colonoscopy with prior bowel preparation is not recommended for patients with acute severe colitis because of the procedural delays and the higher risk of perforation^[84-86]. Although a phosphate-enema preparation before flexible sigmoidoscopy is considered safe, it is best to avoid this with patients with dilated colons^[83]. A routine administration of an oral purgative can cause colonic dilatation and perforation in severely active disease. A flexible

sigmoidoscopy without bowel preparation or with only a phosphate enema before the procedure can be performed to assess endoscopic criteria of colitis and to obtain biopsies for histologic and cytomegalovirus studies^[83,97-99]. In these circumstances, ileocolonoscopy can be postponed until the clinical condition improves^[84].

Colonic cancer surveillance: In a recent study, more than a quarter of IBD patients underwent colonoscopies with longer intervals between them than is recommended (> 3-year intervals on average)^[100]. One factor that could affect adherence to surveillance colonoscopy is bowel preparation. Detection of a flat lesion against an inflamed background is much more difficult, in part because the quality of bowel cleansing is lower with colitis, with an odds ratio of 0.63 (95%CI: 0.40-0.98)^[101]. Good quality preparation with IBD is likely to improve detection rates using mainly oral PEG, especially in cases of remission where the preparation is critical in order to have a reasonable chance of detecting dysplastic lesions^[92].

Several novel techniques have been applied to reduce the required number of biopsy samples and the duration of examinations in the context of cancer surveillance, including chromoendoscopy with or without magnification, narrow-band imaging, fluorescence endoscopy, confocal laser endomicroscopy and optical coherence tomography. These novel procedures require perfect bowel cleansing^[102].

Small bowel studies: In the context of Crohn's disease, the small bowel must be evaluated. Although wireless-capsule endoscopy and antegrade double-balloon enteroscopy can be performed without bowel preparation, most experts recommend bowel cleansing to certify the presence of small-bowel mucosal changes. It is recommended to use 1.5-2.0 L of oral PEG^[103-105]. In a retrograde double-balloon enteroscopy, a standardized bowel cleansing of 2-4 L of PEG is always required^[104,106].

Therapeutic IBD procedures: Excellent bowel preparation with a high volume of oral PEG is necessary in therapeutic settings. The main indications are dilatation of benign fibrotic strictures or polypoid resections^[107,108]. Gastrointestinal hemorrhage is another possible complication of IBD and the presence of endoscopically treatable lesions, though possible, is uncommon^[102].

Elderly patients

Controversies have emerged about the indications for colonoscopy in the elderly. It is known that elderly patients have a higher risk of colorectal cancer^[109]. The most common indications for colonoscopy are gastrointestinal bleeding, anemia, changes in bowel habits and abdominal pain. Elderly patients are more likely to have abnormal colonoscopic findings than younger patients^[110-112]. In fact, colorectal cancer, vascular and diverticular diseases are more common among the elderly^[111,112].

Even though the prevalence of neoplastic lesions

increases with age, the diagnostic yield of a screening colonoscopy among the elderly (aged ≥ 80 years), who have a short life expectancy, is low^[113]. This indicates the limits of screening procedures.

Bowel preparation for colonoscopy among the elderly is an important issue when considering the potential benefits and risks of the procedure. A systematic review and meta-analysis observed that in the included studies, poor bowel preparation was documented in $18.8\% \pm 6.4\%$ of procedures with patients 65 years of age or older, while in patients 80 years or older, poor bowel preparation was reported in $12.1\% \pm 7.6\%$ ^[114]. A study of octogenarians showed that tolerance to 4-L PEG was poor in almost 40%^[115]. Furthermore, tolerance of bowel preparation was evaluated among elderly patients using either PEG or oral NaP in a retrospective study where patients were subdivided into two groups, one under and the other over 65 years of age, with a mean age of the total group of 60.6 ± 14.8 years^[116]. In a separate analysis of adverse events, no significant differences were found between the two preparations, except for nausea, which was experienced by 19% of the PEG group *vs* 39% of the NaP group ($P < 0.009$).

Elderly patients have a higher risk of phosphate intoxication due to a lower glomerular filtration rate, use of medication, and systemic and gastrointestinal diseases. NaP induces electrolyte disturbances such as hyperphosphatemia, hypocalcemia and hypokalemia^[117]. The frequency and severity of hypokalemia is due to intestinal potassium loss associated with inadequate renal potassium conservation and is apparently more prevalent in frail patients. In a retrospective study with elderly hospitalized patients with significant comorbidities, there was a 9.6% ($P = 0.008$) incidence of significant hypokalemia with PEG-based bowel preparation^[118]. However, other studies have suggested that the efficacy of NaP is similar with non-elderly adults and comparable to that of PEG^[119,120].

When assessing the safety of bowel preparation, patients in the PEG group showed fewer changes in the indicators of dehydration and in laboratory tests^[12,121]. Due to its large volume, PEG is contraindicated for patients with impaired swallowing function, such patients with stroke, dementia and Parkinson's disease, all of which are more common among the elderly. As noted above, recent European guidelines for bowel preparation advise against the routine use of oral NaP for bowel preparation due to safety concerns (strong recommendation, low quality evidence)^[1].

As low-volume bowel preparations with PEG have been shown to provide equivalent cleansing with improved tolerability compared to standard PEG bowel preparation for colonoscopy^[34], and the use of a split-dose PEG for bowel preparation before colonoscopy significantly improves the number of satisfactory bowel preparations, increased patient compliance, and decreased nausea compared to full-dose PEG^[20], low-volume PEG in a split-dose modality appears to be the ideal bowel preparation for the elderly. Thus, according to recent consensus guidelines for

bowel preparation prior to colonoscopy, patients with high risk of electrolyte disturbances (elderly and debilitated patients, patients at risk of hypokalemia or hyponatremia) should undergo pre-assessment^[122].

Diabetic patients

Certain conditions of patients, such as diabetes mellitus, are considered a predictor of inadequate bowel preparation for colonoscopy^[67,123]. Many studies have reported poor bowel preparation in diabetic patients compared to non-diabetic patients when using either the same or a higher-volume PEG preparation^[124] or NaP for bowel cleansing. In the latter study, a significant difference in optimal bowel cleansing was achieved in 70% of diabetics compared to 94% of non-diabetics ($P = 0.002$). There was a significant correlation among diabetic patients between the quality of bowel cleansing and mean age, duration of diabetes mellitus, level of hemoglobin A1c, fasting blood glucose level, and late diabetic complications^[125]. Patients with diabetes often have reduced renal perfusion despite normal serum creatinine. It may be necessary to monitor electrolytes after colonoscopy, particularly with patients with cardiac or renal failure.

Patients with renal failure

As mentioned above, fluid and electrolyte shifts can occur as a result of the hyperosmotic nature of NaP preparations^[126]. Consequently, NaP purgatives should not be administered to patients with predisposing factors (*e.g.*, electrolyte abnormalities, renal failure, ascites, congestive heart failure, or a history of myocardial infarction) that can lead to adverse events because of NaP-induced hypovolemia and shifts in serum electrolyte levels. Although electrolyte shifts in patients taking oral or tablet NaP preparations are typically mild, transient and asymptomatic, rare cases of clinically significant hyperphosphatemia have been reported, usually in patients with renal insufficiency^[127].

Moreover, failure to maintain adequate hydration before, during, and after bowel preparation can increase the risk of severe and potentially fatal intravascular volume depletion-related complications. Inadequate hydration appears to be an important element in the reported cases of fatal dysnatraemia associated with PEG preparations^[128] and renal failure associated with NaP preparations^[129]. Therefore, adequate hydration should be maintained throughout the entire bowel preparation process, particularly with high-risk patients such as those taking certain concomitant medications, patients with renal failure, and the elderly.

According to the European Society of Gastrointestinal Endoscopy guidelines for bowel preparation for colonoscopy, PEG is the only recommended bowel preparation for patients with renal failure. The delay between the last dose of bowel preparation and colonoscopy should be minimized and no longer than 4 h^[1].

Patients with heart failure

PEG preparations have been shown to increase plasma

volume of patients with diseases that predispose them to fluid retention^[130]. It has been postulated that this adverse effect occurs less often with lower volume preparations, such as the 2-L PEG regimen combined with bisacodyl or the 2-L PEG 3350 solution. Another concern with PEG solutions is hyperkalemia. Although no clinical reports have shown this finding, the small amount of potassium in this solution is worrisome for patients with heart failure who are taking potassium-sparing diuretics or angiotensin-converting enzyme inhibitors^[46].

Nevertheless, when one considers the risks of fluid shifts with NaP preparations, which are in any event contraindicated for patients with congestive heart failure, the safest preparation for patients with congestive heart failure is either a low-volume PEG preparation or a split dose of a standard volume of PEG preparation with careful monitoring during and after use. Clinicians should emphasize the importance of continuing cardiac medications during bowel preparation when appropriate.

In summary, because PEG formulations are osmotically balanced and do not induce substantial shifts in fluid and electrolyte levels, they can be safely administered to patients with electrolyte imbalance, advance liver disease, poorly compensated congestive heart failure, or renal failure. However, reports of increases in plasma volume among patients with concomitant diseases known to cause fluid retention suggest PEG preparations should be used with caution with such patients

Pediatric patients

Colonoscopy is a key tool in the diagnosis and management of a variety of gastrointestinal tract conditions affecting children and adolescents. To perform such a procedure, the colon must be as clean as possible to effectively detect bowel pathology. Inadequate bowel preparation can lead to poor colonic visualization, missed lesions, increased procedure time, and possibly the need to repeat the procedure. With pediatric populations, it is one of the most difficult parts of the procedure from the patient's perspective.

Over the years, there have been many bowel preparations for children. There is a wide variability in the type, dose and length of bowel preparations at different institutions. Medications that have been used include lavage solutions (PEG with and without electrolytes), osmotic solutions (magnesium citrate), and laxative cleaning agents (senna, bisacodyl, NaP, and phosphate enemas).

There are only a few comparative studies of different bowel preparations with children. Single published randomized trials with pediatric populations demonstrated high efficiency of both PEG with electrolyte solutions and oral NaP^[131-133]. However, oral administration of NaP to children has limitations because of serious adverse effects, such as electrolyte and fluid disturbances and acute kidney injury^[133]. On the other hand, PEG with electrolytes solution also presents of the problems of the high volume required and its unpalatability^[134-139]. Given these problems, alternatives have been studied.

Laxative agents such as bisacodyl and senna have

been evaluated with children, used in combination with clear liquid diets for 2-3 d and enemas^[140,141]. One RCT showed good bowel cleansing with sennosides, whereas bisacodyl with an enema-based protocol had a high rate of poor preparation (37%), resulting in the need for repeated examinations^[141]. Other alternative bowel preparation regimens are based on osmotic agents alone or combined with laxatives^[21,131,132,141-148]. Although excellent or good bowel cleansing rates were reported in 40%-100% of the children, depending on the regimen, these studies are mostly non-randomized, with a limited number of patients. As well, they were evaluated based on a subjective assessment of the overall quality of the bowel preparation.

Currently, PEG without electrolytes is the mainstay for treating constipated children. It has been shown to be effective, safe, palatable, and with excellent compliance^[149]. Because of these properties, PEG has been studied as a bowel preparation option. Two studies have demonstrated that PEG can be used as a safe and effective preparation for children with a dose of 1.5 g/kg for 4 d^[134,150]. However, bowel preparation should ideally be done in a shorter period of time. To establish an effective dose of PEG, a prospective study determined that 1.9 g/kg per day for 2 d with a clear-liquid diet resulted in clear stools in > 90% of patients with excellent/good Aronchick scores^[151]. Another prospective study evaluated a 2-d PEG preparation with 2 g/kg per day PEG with bisacodyl supplementation^[152]. Although demonstrating efficacy (92% excellent/good cleanliness), the study was not blind, lacked a comparison group, and did not assess safety by measuring electrolytes. Recently, Abbas *et al.*^[153] reported a prospective open-label study evaluating a 1-d PEG preparation for children. In the study, 46 children were given 238 g of PEG mixed with 1.9 L of Gatorade over a few hours before the colonoscopy. Only 37 children (82%) ingested the full preparation. Nevertheless, all of the colonoscopies were completed to the cecum, and 77% had effective bowel preparation according to the scale used in the study. Adverse clinical effects were common and included nausea/vomiting (60%) and abdominal pain (44%). There were no clinically significant electrolyte changes. The major advantage of this preparation is a short duration, especially useful for emergency colonoscopies.

Terry *et al.*^[154] recently evaluated the efficacy of PEG and senna for bowel preparation of children. The study was a well-designed blind randomized prospective trial. Thirty patients were randomly assigned to receive PEG at a dose of 1.5 g/kg per day or senna (15-30 mL/d) for 2 d before the colonoscopy. Good/excellent scores for colon cleanliness were given to 88% of patients in the PEG group compared to 29% in the senna group. Both regimens were generally well tolerated without any significant adverse clinical effects or electrolyte changes.

A recent study by Kierkus *et al.*^[155] included 10-18-year-old patients randomly assigned to receive either PEG 60 or PEG 30 mL/kg per day plus oral bisacodyl 10-15 mg/

d (BPEG) or sennosides 2 mg/kg per day for 2 d. Of 240 patients enrolled in the study, 234 patients were available for analysis of the efficacy of colon cleansing. No significant differences were found among the three groups in terms of the proportions of participants with excellent/good (PEG: 35/79; BPEG: 26/79; sennosides 25/76) and poor/inadequate (PEG: 20/79; BPEG: 28/79; sennosides 28/76) bowel preparation evaluated with the Aronchick scale and for the total mean Ottawa score (PEG: 5.47 ± 3.63; BPEG: 6.22 ± 3.3; sennosides: 6.18 ± 3.53). These results showed that high-volume PEG, low-volume PEG plus a laxative stimulant, and sennosides have similar effectiveness and are equally tolerated by patients being prepared for colonoscopy. There were no serious adverse events reported during the bowel cleansing.

Ideal bowel preparations should be effective, safe, and easily accepted by children. It seems that PEG meets these requirements. However, the appropriate duration and dose need to be determined through further randomized and controlled trials.

Patients with acute lower gastrointestinal bleeding

A significant proportion of patients admitted to hospitals have acute lower gastrointestinal bleeding (LGIB). The incidence in the US is about 36/100000 persons, especially among elderly patients that may be taking medications such as anticoagulants or aspirin that interfere with platelet function. Most acute LGIB stops spontaneously without the need for intervention. Furthermore, most cases end without an identified source of bleeding. In such situations there is risk of rebleeding. In more severe episodes of LGIB, it is crucial to identify the source of bleeding; therefore, a therapeutic procedure should be performed. Various studies have identified the most important source of bleeding as diverticula, followed by vascular lesions, both of which can be effectively treated by colonoscopy with good bowel preparation. Some studies have shown that the probability of finding lesions increases with shorter intervals between LGIB and the colonoscopy, though the improvement is not consistent or significant. Consequently, the value of urgent colonoscopy remains controversial^[156-159].

Although there have been reports concerning colonoscopy for acute lower bleeding in which no oral preparation was given, it is now widely accepted that oral preparation plus early colonoscopy achieves better diagnostic and therapeutic performance^[157,160,161]. Moreover, there is risk of explosion when electrocautery is used in patients with unprepared colons, as about 50% of patients have potentially explosive concentrations of hydrogen and methane^[162,163]. To obtain optimal colonic preparation, it is important to first define if an urgent colonoscopy is necessary (performed within hours of admission), which is recommended in more severe cases of LGIB. Different studies have shown that early colonoscopy can reduce the length of hospitalization, which is an important consideration, especially in public hospitals with high demand for beds^[159].

Bowel preparation for urgent colonoscopy: One prospective study involved 121 patients with diverticular hemorrhaging that underwent urgent colonoscopy (within 6-12 h). All patients received a PEG purge, two-thirds orally and one-third by nasogastric tube, and all required 5-6 L of purge and 3-4 h to clean the colon. Notably, 7% (two in the urgent group and three in the routine group) required repeat colonoscopies secondary to inadequate preparation^[164].

In a study by Green *et al.*^[165] in 2005, 50 patients that underwent colonoscopy received PEG (a total of 4-6 L, 250 mL every 15 min) orally or by nasogastric tube for patients that could not drink the solution; 3-4 h were necessary to clean the colon. The elective colonoscopy group was prepared with routine 4-6 L of PEG, administered orally beginning the night before the procedure, which was performed within four days of admission. This study did not mention the quality of preparation, rates of cecal intubation or the duration of the colonoscopy, but it was more successful at finding the source of bleeding in the urgent colonoscopy group (42%) than standard colonoscopy (22%) (OR = 2.6; 95%CI: 1.1-6.2). Nevertheless, there was no difference in terms of the need for surgery or the incidence of rebleeding.

In another randomized trial of urgent *vs* elective colonoscopy among patients that had been hospitalized with LGIB, both groups were prepared with PEG (4 L in 3 h and underwent colonoscopy within 12 h in the urgent group). No benefits were found for the urgent colonoscopy group, and once again, no data was mentioned regarding quality of preparation^[166].

More recently, a feasibility study was conducted on urgent colonoscopy (6-24 h) without traditional preparation. Thirteen patients with severe LGIB were prepared with a combination of three 1-L water enemas 20 min apart. Immediately after the enemas, patients underwent colonoscopy with a hydroflush technique, combining water-jet irrigation and mechanical endoscopic suction, which allows the use of large volumes of water to lavage the colon (500 mL/min). The researchers obtained adequate endoscopic visualization for definitive or presumptive identification of the source of bleeding in all procedures. Cecal intubation was used in 67% of the cases (in the remaining cases a definite or presumptive origin of the bleeding had been detected), the duration of colonoscopy was 38 min, and mean insertion time was 11 min^[167].

In one reported case, an antegrade transendoscopic lavage was applied in a patient with severe lower bleeding, by infusing 4 L of PEG with an irrigation pump at 100 mL/min (over 40 min). This preparation allowed for performing a colonoscopy 8 h later that detected diverticular bleeding^[168]. This approach is similar to the method described by Fujii^[80] for outpatient colonoscopy with a prospective series of 152 patients.

Thus, to obtain a clean colon in the context of LGIB, it is necessary to use a large volume of PEG (4-5 L on average). Up to 50% of cases may require a nasogastric

tube, in which case colon preparation can take 4-6 h. This traditional preparation could be replaced in the future by water-jet techniques that will allow for performing urgent colonoscopy, while avoiding the intake of large amounts of purge or the installation of an NG tube, and likely reducing the length of hospitalization.

CONCLUSION

The importance of an adequate quality of cleansing for colonoscopy cannot be overstated. Efficacy, tolerance, and safety have to be considered when choosing the agent for each patient. The schedule of administration, including timing and the diet chosen, has implications for the quality of cleansing. It is imperative to inform the patient about the importance of colonoscopy and the preparation method, as it is clear now that good information leads to better quality of preparation. Finally, special characteristics of the patients, including comorbidity, must be considered in order to provide them with the safest and more effective method of bowel preparation.

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