

## Factors influencing quality of bowel preparation for colonoscopy

Ronald V Romero, Sanjiv Mahadeva

Ronald V Romero, Division of Gastroenterology, Department of Medicine, University Malaya Medical Centre, Kuala Lumpur 50603, Malaysia

Sanjiv Mahadeva, Department of Medicine, Faculty of Medicine, University of Malaya, Kuala Lumpur 50603, Malaysia

Author contributions: Romero RV and Mahadeva S solely contributed to this paper.

Correspondence to: Sanjiv Mahadeva, MD, MRCP, Department of Medicine, Faculty of Medicine, University of Malaya, Kuala Lumpur 50603, Malaysia. [sanjiv@ummc.edu.my](mailto:sanjiv@ummc.edu.my)

Telephone: +6-3-79494422 Fax: +6-3-79604190

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### Abstract

Recent technological advances in colonoscopy have led to improvements in both image enhancement and procedural performance. However, the utility of these technological advancements remain dependent on the quality of bowel preparation during colonoscopy. Poor bowel preparation has been shown to be associated with lower quality indicators of colonoscopy performance, such as reduced cecal intubation rates, increased patient discomfort and lower adenoma detection. The most popular bowel preparation regimens currently used are based on either Polyethylene glycol-electrolyte, a non-absorbable solution, or aqueous sodium phosphate, a low-volume hyperosmotic solution. Statements from various international societies and several reviews have suggested that the efficacy of bowel preparation regimens based on both purgatives are similar, although patients' compliance with these regimens may differ somewhat. Many studies have now shown that factors other than the type of bowel preparation regime used, can influence the quality of bowel preparation among adult patients undergoing colonoscopy. These factors can be broadly categorized as either patient-related or procedure-related. Studies from both Asia and the West have identified patient-related factors such as an increased

age, male gender, presence of co-morbidity and socio-economic status of patients to be associated with poor bowel preparation among adults undergoing routine out-patient colonoscopy. Additionally, procedure-related factors such as adherence to bowel preparation instructions, timing of bowel purgative administration and appointment waiting times for colonoscopy are recognized to influence the quality of colon cleansing. Knowledge of these factors should aid clinicians in modifying bowel preparation regimens accordingly, such that the quality of colonoscopy performance and delivery of service to patients can be optimised.

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**Key words:** Bowel preparation; Colonoscopy; Risk factors; Quality

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### INTRODUCTION

Colorectal cancer (CRC) is recognized as a significant health problem in both developed and developing countries. In 2008, the worldwide estimated number of new cases of colorectal cancers was 1 233 000 with an estimated mortality of 608 700<sup>[1]</sup>. In Asia, the incidence of colorectal cancer has been noted to be increasing and is already comparable to that of the West<sup>[2-5]</sup>. However, if diagnosed at an early stage, CRC is one of the most preventable and curable malignancies<sup>[6]</sup>. Therefore, screening with the ideal modality can potentially alleviate the health burden of CRC<sup>[7,8]</sup>. Current recommendations on colorectal screening advocate colonoscopy as the preferred modality<sup>[9,10]</sup>, in view of its' accuracy in detecting

early lesions and proven efficacy in lowering rates of incident CRC<sup>[11-14]</sup>. Advances in technology, such as magnification lenses, narrow band imaging and chromoendoscopy have increased the detection yield for early cancers during colonoscopy<sup>[15-17]</sup>. Lesions characterized as early cancers can be endoscopically resected at the same sitting and can be curative<sup>[18,19]</sup>. However, the advantages of colonoscopy are not only limited to the detection and treatment of early cancers. Other therapeutic benefits of colonoscopy include endoscopic hemostasis of bleeding lesions, dilatation of benign strictures and stenting of malignant strictures<sup>[20-23]</sup>.

Despite these advances in diagnostic and therapeutic colonoscopy, the utility of colonoscopy remains dependent on the cleanliness of the colon or the quality of bowel preparation. For instance, adenoma detection rate, being one of the quality indicators of colonoscopy, is recognized to be decreased by poor bowel preparation<sup>[24-26]</sup>. Colonoscopy performance is also significantly affected by poor bowel preparation. In a recent study among Asian patients, poor bowel preparation resulted in decreased cecal intubation, prolonged cecal intubation and total colonoscopy time, and increased patient discomfort<sup>[27]</sup>. In similar studies in Europe and Australia, poorly prepared patients during colonoscopy had longer, more difficult procedures and a lower diagnostic yield for polyps<sup>[28-30]</sup>.

## GRADING OF BOWEL PREPARATION

Many clinical studies have used the terms “excellent”, “good”, “fair”, and “poor” to rate the quality of bowel preparation<sup>[31-34]</sup>. “Excellent” is typically defined as no or minimal solid stool and only small amounts of clear fluid that require suctioning. “Good” is typically used to describe no or minimal solid stool with large amounts of clear fluid that require suctioning. “Fair” generally refers to collections of semisolid debris that are cleared with difficulty. “Poor” generally refers to solid or semisolid debris that cannot be cleared effectively. For practical purposes, an unsatisfactory or inadequate bowel preparation is one which would use a combination of the descriptions of “fair” and “poor”.

## BOWEL CLEANSING AGENTS

Several colon cleansing agents and schedules have been utilized and studied for bowel preparation during colonoscopy. The most popular regimes today are based on either polyethylene glycol-electrolyte (PEG) lavage solution or aqueous sodium phosphate solution<sup>[35-38]</sup>. PEG is a non-absorbable solution that should pass through the bowel without net absorption or secretion<sup>[39]</sup>. Significant fluid and electrolyte shifts are therefore avoided but large volumes (4 L) are still required to achieve a cathartic effect. Sulphate-free PEG (SF-PEG) is more palatable with improved aroma and taste than pure PEG solutions. A reduced-volume (2 L) preparations coupled

with irritant laxatives, such as bisacodyl or magnesium citrate<sup>[40]</sup>, was developed to increase patient compliance and is recognised to be as effective as the standard 4 L PEG preparation<sup>[41-43]</sup>. Aqueous sodium phosphate is a low-volume hyperosmotic solution which contains 48 g (400 mmol) of monobasic sodium phosphate and 18 g (130 mmol) of dibasic sodium phosphate per 100 mL. Sodium phosphate osmotically draws plasma water into the bowel lumen to promote colonic cleansing and significant fluid and electrolyte shifts can occur<sup>[39]</sup>. Two meta analyses, comprising 71 trials (10 201 subjects) and 18 trials (2792 subjects) respectively, previously concluded that sodium phosphate-based bowel preparations resulted in a more complete and better quality of bowel preparation compared to 4-L PEG<sup>[44,45]</sup>, mainly due to the poorer compliance with the latter<sup>[46-49]</sup>. However, sodium phosphate is associated with significant fluid and electrolyte shifts due to its hyperosmotic nature and patients with renal impairment, dehydration, on angiotensin-converting enzyme inhibitors, or angiotensin receptor blockers can develop renal failure<sup>[50-52]</sup>.

The recent American Society for Gastrointestinal Endoscopy, American Society of Colon and Rectal Surgeons, and the Society of American Gastrointestinal and Endoscopic Surgeons consensus statements on bowel preparation evaluated the use of PEG, SF-PEG, low-volume PEG/PEG-3350 with bisacodyl delayed-release tablets, aqueous and tablet preparations of sodium phosphate, the data of which has been summarised in Table 1<sup>[50]</sup>. There is little variation in bowel preparation regimens in other countries. The European Society of Gastrointestinal Endoscopy recommended 4 L polyethylene glycol with low-dose sodium phosphate boosts as bowel preparation for colon capsule endoscopy<sup>[53]</sup>. Similarly in a bowel preparation study in South Korea, subjects were given PEG solutions in 4 L of water<sup>[54]</sup>. In Canada, as described in the position paper of the Canadian Association of Gastroenterology, the most commonly used bowel preparation agents are polyethylene glycol, sodium phosphate, magnesium citrate, and sodium picosulfate, citric acid, and magnesium oxide-containing solutions<sup>[55]</sup>. In a colonoscopy practice study in the United Kingdom comprising of 9223 colonoscopies, bowel preparation was performed using sodium picosulfate, polyethylene glycol preparations and sodium phosphate in 36.8%, 20.7% and 15.6% of colonoscopy procedures respectively<sup>[56]</sup>.

Regardless of the type of bowel preparation used, whether it is PEG or sodium phosphate-based, both types appear to have a similar level of bowel cleansing ability. Modifications of these two common types of bowel preparations, such as adding prokinetic agents to PEG<sup>[57,58]</sup>, or adding simethicone to sodium phosphate<sup>[59]</sup>, may provide some improvements in certain instances. However, it is recognized that factors other than the type of bowel cleansing agent used, have an equally, if not more, important role in influencing the quality of bowel preparation in patients undergoing colonoscopy. In gen-

**Table 1 Summary of American Society for Gastrointestinal Endoscopy, American Society of Colon and Rectal Surgeons, Society of American Gastrointestinal and Endoscopic Surgeons consensus recommendations on colon cleansing agents for bowel preparation during colonoscopy**

Agent	Dosing	Recommendation	Level of evidence
PEG	240 mL every 10 min until rectal output is clear or total of 4 L	Faster, more effective, better-tolerated compared to dietary restriction with cathartics, gut lavage, or mannitol	Grade I A
Sulfate-free PEG	240 mL every 10 min until rectal output is clear or total of 4 L	Better tasting, comparable to PEG in effectiveness and safety, acceptable alternative to PEG	Grade II B
Low-volume PEG/PEG-3350 and bisacodyl	4 bisacodyl delayed-release tablets at noon, after bowel movement or 6 h, 240 mL every 10 min until 2 L is consumed	Equally effective to standard 4-L PEG, better tolerated, acceptable alternative to 4-L PEG	Grade I A
Aqueous sodium phosphate	Two doses of 30 to 45 mL sodium phosphate with 8 oz of liquid 10-12 h apart	Equal alternative to PEG except for pediatric and elderly patients, bowel obstruction, renal failure, congestive heart and liver failure	Grade I A
Sodium phosphate tablets	20 tablets on the evening before the procedure, 12-20 tablets 3-5 h before the procedure	Improved taste and palatability compared to aqueous sodium phosphate, but no improvement in patient tolerance	Grade I A

PEG: Polyethylene glycol-electrolyte.

eral, this can be categorized as either patient-related (*i.e.*, clinical or epidemiological parameters) or procedure-related (*e.g.*, administrative issues relating to bowel preparation or the conduct of colonoscopy) factors. In this review, we will focus on both of these factors and their influence on the quality of bowel preparation among adult patients undergoing colonoscopy.

## PATIENT-RELATED FACTORS

### Age

Several studies have evaluated advancing age as a risk factor for poor bowel preparation in colonoscopy. In a retrospective United States study of 300 patients, univariate analysis demonstrated that a mean age of  $\geq 66$  years was predictive of poor colonoscopy preparation<sup>[60]</sup>. In two recent Asian studies, age  $\geq 60$  years were similarly associated with a poor bowel preparation<sup>[27,54]</sup>. An increased age is known to be associated with a reduced colonic transit, greater co-morbidity and polypharmacy, all of which are known to impact on colonic cleansing<sup>[39,61-64]</sup>. However, in a larger prospective study of 649 patients, the age of patients did not appear to have an impact on the quality of bowel preparation in patients undergoing colonoscopy<sup>[65]</sup>. One possible explanation was that the mean age of patients in this study was 56 years, which is significantly lower than other studies which reported on age as a risk factor for poor bowel preparation.

### Gender

Studies in both the West<sup>[65,66]</sup> and the East<sup>[67]</sup> have demonstrated that male gender is an independent predictor of poor bowel preparation. Among 649 American patients, of whom 21.7% had poor bowel preparation, Ness *et al.*<sup>[65]</sup> reported that male gender was an independent predictor of poor bowel preparation among other patient-related factors. Chan *et al.*<sup>[67]</sup> showed that male patients undergoing colonoscopy were 1.6 times more

likely to have poor bowel preparation compared to female patients, in a study of 501 Asian patients. Leibold further reported that male patients had a 1.4 times risk of poor bowel preparation compared to females in yet another American study of 10 921 patients undergoing colonoscopy<sup>[66]</sup>.

It is well known in most societies that men are less health-conscious compared to women for various reasons<sup>[68-70]</sup>. Gender differences in reproductive biology, higher morbidity rates in women than in men, differences in health perceptions and the reporting of illnesses, and a greater likelihood that women seek help for prevention of illness<sup>[71]</sup> are some of the explanations for a lesser healthcare attitude amongst men. It is plausible then that this gender difference may have led to a poorer adherence to bowel preparation instructions among male patients undergoing colonoscopy from both Eastern and Western patients.

### Co-morbidity

Several studies have managed to explore the association between co-morbidities and adequacy of bowel preparation. A recent study of 300 outpatients undergoing colonoscopy identified the “use of more than 8 active prescription medications”, *i.e.*, a surrogate marker for co-morbidity as a predictor for poor bowel preparation<sup>[72]</sup>. Among the common chronic illnesses known, diabetes has been shown to be consistently associated with poor bowel preparation. In a South Korean study of 367 patients, Chung *et al.*<sup>[54]</sup> demonstrated that diabetic patients had a 8.6 times risk of poor bowel preparation compared to non-diabetic patients. In yet another study specifically comparing standard PEG bowel preparation between diabetic and non-diabetic patients, Taylor *et al.*<sup>[73]</sup> demonstrated that an adequate bowel preparation was found in 97% non-diabetic patients compared to 62% of diabetic patients. Diabetes is known to impair colonic and general gastrointestinal transit<sup>[74,75]</sup>, and it is this mechanism that is thought to result in a poorer bowel

preparation.

Patients with stroke disease and dementia have additionally been demonstrated to have a higher risk of poor bowel preparation<sup>[65]</sup>, potentially as a result of an altered gastrointestinal motility as well and their inability to comply with bowel preparation instructions. A single study has additionally identified prior gastrointestinal and pelvic surgery as risk factor for inadequate bowel preparation<sup>[54]</sup>.

The setting in which patients are referred for a colonoscopy, *i.e.*, either from an in-patient or out-patient setting, is yet another surrogate marker for the impact of co-morbidity on level of colon cleanliness. Inpatient status has been associated with poorer bowel preparation in several studies<sup>[65,67,76]</sup>, and this has been attributed to prolonged immobility and poor tolerance to purgatives due to co-morbid illness. Even in colonic surgery, an out-patient bowel preparation, as opposed to an in-patient preparation, has been shown to result in a better clinical outcome due increased co-morbidity in the latter<sup>[77]</sup>.

### **Socioeconomic status**

Bowel preparation regimens need to be adhered to ensure a good quality of preparation during colonoscopy (see later). As standard bowel preparation usually requires a combination of dietary restrictions and several steps of purgative administration, a clear understanding of the process and strict adherence to instructions (usually in a written format) is vital. A poor understanding of this process, and its' importance, has been shown to be more prevalent among patients from a lower socioeconomic background. A recent United States-based study identified poor bowel preparation to be more common among patients who needed English-language interpretation (for bowel preparation instructions) and those on Medicaid insurance (a marker of low socioeconomic status)<sup>[72]</sup>. A lower education level, as a marker of lower socioeconomic status, was recently shown to be an independent predictor of poor bowel preparation in an Asian study of 501 outpatients<sup>[67]</sup>. In contrast, enhanced education and specific counseling of adult patients on bowel preparation instructions was shown to improve the quality of bowel preparation in an elegant Canadian study of 38 patients<sup>[76]</sup>.

## **PROCEDURE-RELATED FACTORS**

### **Adherence to bowel preparation instructions**

As mentioned before, a standard bowel preparation usually involves several steps. Regardless of the type of purgative used, non-adherence to these steps alone have been shown to be an important determinant of quality of bowel preparation. Among several other factors which predicted poor bowel preparation, Ness *et al.*<sup>[65]</sup> had identified that a failure to adequately follow preparation instructions was associated with a 2.68 odds ratio for predicting poor bowel preparation. In a recent

American study of 300 patients who underwent screening colonoscopy for cancer, Nguyen *et al.*<sup>[72]</sup> reported that 86.7% of patients with a poor/inadequate bowel preparation had failed to either complete the bowel preparation or follow written instructions. These findings were similarly reported in a Malaysian study of 501 patients, whereby non-adherence to purgative instructions was associated with a 4.76 risk of poor bowel preparation<sup>[67]</sup>. Whilst non-adherence to preparation instructions is an obvious determinant of the quality of bowel preparation, it is generally unreliable as it depends on self-reporting by patients. It is well recognized that many patients are reticent to admit non-adherence or they may not even recognize non-compliance themselves<sup>[65]</sup>. Nevertheless, it is important to identify factors contributing to non-adherence of instructions as this provides an opportunity to intervene and enhance quality. A lower socioeconomic status has been identified as one of the main reasons for non-adherence to bowel preparation instructions<sup>[72]</sup> and it is likely that male gender may be a contributing factor<sup>[66,67]</sup>, for reasons outlined previously.

### **Timing of bowel preparation administration**

Several studies have examined the effect of timing of bowel purgative administration (mostly PEG) and its' impact on quality of bowel preparation. In a large study of 317 patients undergoing an afternoon colonoscopy, Church *et al.* demonstrated that a "same-day" administration resulted in a significantly better quality of bowel preparation compared to a "one day before" timing, using the same quantity of PEG solution<sup>[78]</sup>. Regardless of the location of the colon, patients with a "same day" bowel preparation had a greater proportion of "excellent grade" cleanliness and a lower proportion of "fair grade" cleanliness compared to patients who had consumed purgatives the day before<sup>[78]</sup>. Two other studies examining "day before" *vs* "same day" preparations have managed to demonstrate a similar superior efficacy of the "same day" preparations<sup>[79,80]</sup>, with an Italian study even suggesting that this timing improved the detection rates of colonic adenomas<sup>[80]</sup>. A prolonged duration between purgative administration and timing of colonoscopy is thought to result in proximal colon contamination from the small bowel and hence a poorer colon cleansing ability. In a different study, El Sayed *et al.*<sup>[81]</sup> investigated the effect of a split-dose administration of PEG, whereby 187 patients were randomised to either "3 L PEG + dietary restriction one day before" *vs* "2 L PEG + Bisacodyl one day before + 1 L PEG on the same day" of the colonoscopy procedure. Although a little more complicated, the authors were able to demonstrate that the split-dose regime was better tolerated and resulted in better colon cleansing.

### **Appointment waiting time**

The time from booking a routine colonoscopy procedure to the actual appointment date, *i.e.*, the appointment

**Table 2** Predictive factors for quality of bowel preparation independent of colon cleansing agent

Patient-related factors	Procedure-related factors
Age > 65 yr	
Male gender	Adherence to bowel preparation instructions
Co-morbidity	Timing of purgative administration
Diabetes	
Stroke disease	
Inpatient status	
Low socioeconomic status	Appointment waiting times

waiting time, may influence the quality of bowel preparation due to individual patient's ability to recall bowel preparation instructions. To date, a single study among Malaysian patients in a public institution has demonstrated that a prolonged appointment waiting time of > 16 wk was associated with a 1.86 risk of poor bowel preparation<sup>[67]</sup>. A previous retrospective study in the United States did not identify appointment waiting times as a risk factor for poor bowel preparation, but the mean waiting time was only 4.39 wk in this study<sup>[72]</sup>. Whilst most endoscopy units strive to shorten their outpatient waiting times for appointments for index colonoscopies, the increasing demand from colorectal cancer screening together with limited resources in most healthcare systems requires urgent attention.

## CONCLUSION

Preferences for either PEG or phosphate-based purgative preparations may differ between populations. Nevertheless, it is apparent that patient-related or procedure-related factors, summarized in Table 2, have a significant influence on the quality of bowel preparation among adults undergoing colonoscopy. Although not all factors can be necessarily addressed, modifying the standard bowel preparation regime for such patients may enhance the quality of bowel preparation, reducing the negative impact of poor bowel preparation on individuals and colonoscopy services as a whole.

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