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Research progress on improving the quality of bowel preparation before colonoscopy

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Abstract: *Colonoscopy is the first choice for the diagnosis and treatment of colorectal diseases, and its value and importance are increasing. The quality of bowel preparation before colonoscopy directly affects the accuracy of colonoscopy diagnosis and the safety of colonoscopy treatment. In recent years, more and more attention has been paid to the importance and safety of bowel preparation at home and abroad, and relevant bowel preparation guidelines have been published at home and abroad. This article reviews the research progress of bowel preparation before colonoscopy in recent years, in order to improve the quality of bowel preparation and improve the clinical outcomes of colorectal diseases.*

Keywords: *Colonoscopy; Bowel preparation; Colorectal cancer*

1. Introduction

Colorectal cancer (CRC) is one of the most common malignant tumors in the world. The incidence of CRC ranks third in both China and Europe, with a wide range of age groups, a high postoperative recurrence rate, a serious impact on the quality of life of patients, and a serious economic burden on patients and society, which is a global public health problem that cannot be ignored [1]. Colonoscopy is the most direct and effective method for the diagnosis of early CRC and precancerous lesions, and is the gold standard for the diagnosis of CRC [2]. The treatment of early lesions under colonoscopy can completely remove the lesions, reduce surgical operation, and has the advantages of good curative effect and rapid healing. However, the safety and accuracy of colonoscopy largely depend on the cleanliness of the bowel. Good intestinal cleanliness can reduce the time of intestinal irrigation, improve the rate of terminal ileum intubation and the detection rate of adenocarcinoma. However, poor intestinal cleanliness and residual feces can cover the lesion, leading to missed diagnosis or even interruption of the examination, requiring a second colonoscopy, which increases the physical and economic burden of patients. Although the methods of bowel preparation before colonoscopy are constantly improved, inadequate bowel preparation is still as high as 20-30% in clinical work [3]. Therefore, how to improve the quality of bowel preparation for colonoscopy is still a problem worth exploring. This article reviews a large number of domestic and foreign literature related to bowel preparation, and summarizes the interventions to improve the quality of bowel preparation for patients undergoing colonoscopy.

A complete bowel preparation program should include preoperative education, diet management, bowel emptying, and quality assessment.

2. Overview of bowel preparation

High-quality bowel preparation is the basic condition for colonoscopy, and the adequacy of bowel preparation determines the success or failure of colonoscopy. Colonoscopy is the main method for diagnosis, screening and treatment of colonic lesions because it can visually observe the entire rectal mucosa. High-quality bowel preparation is helpful to improve the intestinal cleanliness and comfort of patients, so that endoscopicologists can clearly observe the lesions on the inner wall of the field, including ulcers, polyps and masses. Complete sampling provides better conditions for endoscopic examination and treatment. The poor quality of bowel preparation will reduce the accuracy of adenocarcinoma detection, prolong the operation time, shorten the interval time of second colonoscopy, and increase the medical and economic burden of patients.

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3. Preoperative education of bowel preparation

Preoperative education is the first step of bowel preparation, which is of great significance to the final quality of bowel preparation. The contents of preoperative education mainly included informing patients about the importance of bowel preparation, the type and time of preoperative diet, the time, dose and timing of the use of intestinal cleansing agents, coping with adverse reactions, and the importance of compliance. Traditional preoperative education mainly adopts face-to-face oral explanation, telephone communication, SMS reminder, text materials, pictures and images [4], and wechat public accounts, popular science small videos and other forms of education are the mainstream education methods. Spiegel et al. evaluated patients' cognitive level of bowel preparation and formulated an education manual for bowel preparation before colonoscopy based on the interview results. The research results showed that individualized bowel preparation education manual could significantly improve the quality of bowel cleaning of patients, but the effect on the examination results was not clear [5].

With the widespread use of smart phones and their apps, a variety of medical information can be quickly and completely transmitted to patients, including pictures, videos, etc. Illustrated, clear and easy to follow instructions play a positive role in the quality of bowel preparation [6]. Zander et al. compared bowel preparation instructions provided through a personalized smartphone app with traditional written instructions for bowel preparation to improve bowel preparation quality. A total of 87 patients were included in the smartphone app group and 86 patients were included in the control group. Scores on the Boston Bowel Preparation Scale were significantly higher in the smartphone-app group than in the control group. The right colon showed significantly higher bowel preparation scores in the smartphone app group. In particular, in the right colon, there was an increase in the Boston Bowel Preparation Scale score, which is clinically relevant because the right colon is considered more difficult to clean, and the polyp detection rate in the right colon increases with improved bowel cleaning in the right colon [7]. Chen et al. applied VR technology to preoperative education, and the results showed that the Boston Bowel Preparation Scale score of the VR video group was significantly higher than that of the control group. Polyp detection rates and adenoma detection rates were also higher in the VR video group. Patients who received VR education had better compliance with bowel preparation. In addition, it can reduce the anxiety of patients before colonoscopy and improve patient satisfaction [8]. With the help of modern information technology, the implementation of enhanced preoperative education of bowel preparation, the quality of bowel cleaning of patients is significantly higher than that of the traditional education model, and the compliance and satisfaction are also higher [9]. However, there are a considerable proportion of elderly patients undergoing colonoscopy, with low education level, decreased physiological function and insufficient cognitive ability. All of them cause obstacles to the application of new technologies [10]. How to do a good job in preoperative education for this group is a problem worth studying.

4. Dietary management of bowel preparation

Diet prior to colonoscopy may directly affect the quality of bowel preparation. Chinese and European guidelines recommend a low-fiber diet during bowel preparation for colonoscopy [11-12]. Dietary requirements for precolonoscopy varied across regions of the country, with 91% of endoscopy centers requiring a liquid diet the day before colonoscopy to adequately clean the bowel and 9% recommending a low-fiber or normal diet the day before the procedure. Liquid diet before colonoscopy can cause insufficient energy intake, increased gastrointestinal reactions, fatigue, dizziness and even hypoglycemia, and other adverse reactions, resulting in decreased patient satisfaction and compliance [13]. A study from the University of California, Irvine showed better bowel preparation quality in patients on a low-fiber diet before colonoscopy than in those on a liquid diet. As a less restrictive dietary option, a low-fiber diet may help increase patient participation in colorectal cancer screening programs [14]. A Korean study comparing the effects of regular versus liquid diet on bowel cleanliness before bowel preparation showed no significant difference in bowel cleanliness quality between liquid and regular diet groups, and a full day of liquid diet before colonoscopy should not be mandatory. At least for healthy patients, dietary education to avoid high-fiber foods for 3 days prior to colonoscopy is sufficient [15]. A multivariate analysis study on intestinal cleanliness showed that normal diet before colonoscopy did not reduce intestinal cleanliness, but red meat, poultry and high-fiber vegetables should be avoided [16]. Choosing a regular diet does not significantly affect intestinal cleanliness. It can improve patient compliance and make patients more willing to accept and abide by dietary advice [17].

The use of standardized prepackaged low-residue diet can improve the quality of bowel preparation

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and the compliance and satisfaction of patients with bowel preparation. The results of this study are consistent with the conclusion of a foreign study, suggesting that standardized prepackaged low-residue diet can play a great role in the process of diet preparation before endoscopy [18].

5. Intestinal cleansing

Bowel cleansing methods are mainly divided into two main categories, oral bowel cleansing preparations and enema.

5.1 Oral bowel cleansing preparations

There are many kinds of oral intestinal cleansing preparations, and there are three categories at present, which are divided into volumetric laxatives, irritating laxatives and traditional Chinese medicine. Common polyethylene glycol electrolyte powder (PEG), magnesium sulfate, sodium phosphate salt and mannitol all belong to volumetric laxatives, irritating laxatives include bisacridine and Picosulfate sodium, etc. Senna leaf and castor oil are common laxatives in traditional Chinese medicine [19].

PEG is the most widely used intestinal cleanser at home and abroad. It is an inert polymer formed by ethylene oxide.As a volumetric laxative, it can be cleaned by oral administration of a large amount of liquid, which has no obvious effect on the absorption and secretion of the intestine, and does not cause water and electrolyte disorders. Magnesium sulfate is also widely used, but magnesium salt may cause changes in mucosal morphology and cause intestinal mucositis and ulcers, so it is not recommended for patients with confirmed or suspected enteritis. Magnesium ions can accumulate in the body and cause hypermagnesemia, so it is not recommended for patients with abnormal renal function. Sodium phosphate is widely used in foreign countries, and its mechanism of action is similar to that of magnesium sulfate, which can also cause mucosal lesions. At the same time, excessive use of sodium phosphate as a hypertonic solution may cause electrolyte disorders, such as hyperphosphatemia, hypocalcemia, hypernatremia, hypokalemia, dehydration, etc. It should be used with caution in the elderly, patients with kidney disease, electrolyte disorders, heart failure, and abnormal liver function. The effect of sodium phosphate solution on intestinal cleaning is similar to that of PEG, but the sodium phosphate solution usually needs about 1500ml, and the gastrointestinal adverse reactions such as abdominal distension, nausea and vomiting are less, and the patients are easy to tolerate. It is often used in patients who cannot tolerate PEG and magnesium sulfate. Pick sodium sulfate preparation should be used with caution in patients with hypovolemia, congestive heart failure, advanced liver cirrhosis and renal disease. At the same time, it can also cause intestinal mucosal inflammatory changes. Bisacridine usually has a good intestinal cleansing effect, but occasionally it can cause obvious abdominal pain, and patients' acceptance is low. Some hospitals in China used to use senna as an intestinal preparation drug, which can directly stimulate the nerve plexus of the intestinal wall, promote intestinal peristalsis, inhibit water absorption, and achieve the purpose of cleaning the intestine. However, severe abdominal pain and abdominal distension are its obvious side effects, and its clinical application has become less and less [20].

5.2 Dose and timing of intestinal cleansing

PEG is the most commonly used intestinal cleansing agent at home and abroad, but there are significant differences in the dosage between the European and American guidelines and the domestic guidelines, which may be related to the differences in body size. European and American guidelines believe that 4L of PEG solution can obtain an ideal intestinal cleansing state [21], while domestic guidelines generally recommend 2L of PEG solution for intestinal cleansing [22]. Taking 2 liters of PEG solution for bowel preparation on the day of examination has better cleaning effect and safety, with less discomfort, and is more suitable for Chinese people. The possible reason is that the body weight of Chinese people is significantly lower than that of European and American people.

The time of taking PEG is also very important. Foreign studies have shown that bowel preparation on the night before examination takes longer time, which affects the sleep of patients. Bowel preparation on the day of examination can achieve better intestinal cleaning effect, so bowel preparation is recommended on the day of examination [23]. Split-dose administration of PEG solution has also attracted the attention of scholars at home and abroad. Domestic studies have shown that split-dose administration of PEG solution has a significantly better intestinal cleaning effect than single-dose administration and is more acceptable to patients [24]. At present, the European and American guidelines recommend a split-dose regimen, which can increase the effectiveness and tolerability of bowel preparation. For patients

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undergoing elective colonoscopy, split-dose bowel cleansing (one half of the cleansing solution administered the day before and on the day of the examination) was strongly recommended, and patients were more likely to repeat the procedure than those who were given the cleansing solution the day before the examination. The degree of cooperation is higher [21].

5.3 Use of adjunctive drugs

In order to remove foam and improve the visibility under the microscope, endoscopists need to frequently wash and suction, which increases the operation steps and prolongs the examination time, resulting in pain and discomfort for patients and reducing patient compliance. Dimethicone or simethicone can reduce the surface tension of bubbles, and it is not absorbed by the blood, and the safety is high. The meta-analysis results of a randomized controlled trial (RCT) study showed that patients who did not receive dimethylsilicone oil in bowel preparation had a higher incidence of bubbles affecting the observation, but there was no difference in the degree of intestinal cleanliness [25]. To remove air bubbles in the intestine, dimethylsilicone oil can be used as an adjunct. The most commonly used dose of dimethylsilicone oil is 120 to 240mg (3 to 6mL of simethicone) or 300g/L solution 45mL, which can be used with laxatives [26].

6. Intestinal cleaning quality assessment

The quality of bowel cleanliness in colonoscopy needs to be objectively evaluated by a suitable scale, which is commonly used in China to be graded according to bowel cleanliness (see Table 1).

Table 1: According to the degree of observation of feces, fecal water residue and visual field, it was divided into grade IV from good to poor

I	The intestinal preparation was excellent, and there was no fecal residue and fecal water in the intestinal cavity
II	The bowel was well prepared, and there was no fecal residue in the intestinal cavity, only fecal water remained, and the vision was clear after suction
III	Poor bowel preparation, more fecal residue, fecal water retention, blurred vision, can only be clearly observed after washing
IV	Poor bowel preparation, residual fecal mass in the intestinal lumen, blurred vision and inability to observe

At present, the commonly used scoring scales in the world include Aronchick bowel preparation scale (ABPS), Ottawa bowel preparation scale (OBPS), Boston Bowel Preparation Scale (BBPS), and Harefield bowel preparation scale (HBPS). Each scale has advantages and disadvantages, but in general the assessment criteria have become more comprehensive.

ABPS is internationally recognized as the earliest scale used to evaluate the quality of bowel cleanliness. The scale is simple to use and can be scored by endoscopists after flushing and aspirating the bowel, but it only quantifies the whole colon as a percentage and does not assess segments, which is quite limited (see Table 2).

Table 2: Aronchick bowel preparation scale

1	There was a small amount of clear fluid, and more than 95% of the mucosa was visible
2	A large amount of clear fluid was seen, and more than 90% of the mucosa was visible
3	Semisolid stool with more than 90% mucosa visible after rinsing
4	Semisolid stool could not be washed and aspirated, and less than 90% of the mucosa was visible
5	Large amount of solid stool, requiring re-bowel preparation

The OBPS was developed in 2004 on the basis of the ABPS (see Table 3). The colon was divided into three segments, namely the right colon (cecum and ascending colon), the middle colon (transverse colon and descending colon), and the rectum and sigmoid colon, which effectively improved the reliability of endoscopists' assessment of intestinal cleanliness. The score was scored separately according to the amount of fecal water remaining in the whole colon: 0 for small amount, 1 for moderate amount, and 2 for large amount. When the scores of the two parts are added together, lower scores indicate better intestinal cleanliness, but OBPS is difficult to specifically assess the amount of fecal water remaining in the intestine.

BBPS (see Table 4) is a bowel preparation scale proposed in 2009, which can objectively reflect the

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cleaning effect of bowel preparation and is currently considered as a reliable bowel preparation evaluation scale in clinical practice. The colon was divided into three segments, namely the left colon (descending colon, sigmoid colon and rectum), transverse colon (hepatic flexure and splenic flexure) and right colon (cecum and ascending colon). The cleaning effect of each segment was scored as the sum of the three parts, and the higher the score, the better the cleaning effect.

Table 3: Ottawa bowel preparation scale

0	The bowel was prepared and the mucosa was clearly visualized
1	The mucosa was mildly but clearly visible
2	Fecal water is present and suction operation is required
3	There was residual fecal residue, which required washing and suction
4	There was solid stool and part of the mucosa could not be visualized

Table 4: Boston Bowel Preparation Scale

0	Solid feces could not be removed from the intestinal tract, and the mucosa could not be observed clearly
1	There was much residual stool or opaque fluid, and only part of the intestinal mucosa could be clearly observed
2	A small amount of fecal residue or opaque fluid remained, and most of the intestinal mucosa could be clearly observed
3	There was no fecal residue and opaque fluid, and the whole segment of intestinal mucosa could be clearly observed

In 2013, the latest and most rigorous HPBPS in the world was published by combining OBPS and BBPS (see Table 5), which divided the colon into 5 segments and graded each segment. However, due to the complexity of its scoring and the lack of clear verification of clinical effectiveness, it has not been widely used in clinical practice.

Table 5: Harefield bowel preparation scale

0	Large amounts of solid stool cannot be removed
1	Semi-solid fecal residue, partially mobile
2	Movable, cloudy liquid fecal residue
3	transparency liquid
4	No liquid residue

Based on the analysis of the advantages and disadvantages of the above commonly used bowel cleanliness assessment scales, the BBPS can objectively and effectively evaluate the bowel cleanliness, and the assessment method is relatively simple. The bowel cleanliness scale is recommended by the American Colorectal Cancer Multi-center Working Group and the Digestive Endoscopy Committee of Chinese Medical Doctor Association.

7. Summary

Individualized bowel preparation programs are increasingly used in clinical practice. Different protocols can indirectly affect the effect of colonoscopy by affecting intestinal cleanliness. With the development of convolutional neural network, artificial intelligence system has gained more application and recognition in the field of medicine. After more research and verification of the scale, it will be affected by subjective evaluation. There are subjective differences between observers. Bowel preparation should be multidisciplinary, involving all subjects, nurses, doctors and information professionals. Medical staff need to choose the best plan and the best assessment method for each patient, so as to provide patients with better quality and more accurate colonoscopy diagnosis and treatment services.

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