

The incidence of and risk factors for inadequate bowel preparation in elderly patients: A prospective observational study

Yuan-Yuan Zhang^{1,2}, Mei'e Niu³, Zhen-Yun Wu², Xi-Ya Wang¹, Yuan-Yuan Zhao², Jie Gu¹

¹Departments of Gastroenterology and ³Nursing, The First Affiliated Hospital of Soochow University, ²Department of Medicine, School of Nursing, Soochow University, Suzhou, China

Abstract

Background/Aim: We conducted a prospective observational study to identify the incidence of and risk factors for inadequate bowel preparation in elderly Chinese patients.

Patients and Methods: We enrolled 240 outpatients over 60 years of age scheduled for elective colonoscopy at our university hospital between November 2016 and April 2017. We recorded patient demographics, bowel preparation data, and clinical characteristics. Factors associated with inadequate bowel preparation were identified by multivariate logistical regression analysis.

Results: The rate of inadequate bowel preparation was 34.6%. Factors associated with inadequate bowel preparation were a history of abdominal surgery (OR, 2.617; CI, 1.324–5.174; $P = 0.006$), chronic constipation (OR, 3.307; CI, 1.551–7.054; $P = 0.002$), non-compliance with dietary instructions (OR, 2.239; CI, 1.122–4.471; $P = 0.022$), non-compliance with polyethylene glycol (PEG) dosage (OR, 4.576; CI, 1.855–11.287; $P = 0.001$), walking <30 minutes during preparation (OR, 2.474; CI, 1.261–4.855; $P = 0.008$), interval between PEG ingestion and the onset of bowel activity (OR, 1.025; CI, 1.010–1.040; $P = 0.001$), and a last stool that was not clear and watery (OR, 4.191; CI, 1.529–11.485; $P = 0.005$).

Conclusion: The incidence of adequate bowel preparation in elderly patients is not optimal. Walking <30 minutes during the PEG ingestion period may be a surrogate for bowel preparation failure. Future studies should identify elderly patients at risk for poor bowel preparation and develop interventions to improve outcomes in this population.

Keywords: Bowel preparation, colonoscopy, elderly patients, risk factors

Address for correspondence: Mei'e Niu, Department of Nursing, The First Affiliated Hospital of Soochow University, Suzhou 215006, China.
E-mail: menu@suda.edu.cn

See accompanying editorial on page 73

INTRODUCTION

Colorectal cancer (CRC) is a serious public health problem

because of its high morbidity and mortality.^[1] Recently, the incidence of CRC has increased rapidly in China, and CRC is now the third leading cause of cancer-related death.^[2] Early detection and removal of adenomatous polyps can reduce the risk for development of CRC. Colonoscopy is widely considered the gold-standard method for diagnosing

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Zhang YY, Niu M, Wu ZY, Wang XY, Zhao YY, Gu J. The incidence of and risk factors for inadequate bowel preparation in elderly patients: A prospective observational study. *Saudi J Gastroenterol* 2018;24:87-92.

Access this article online	
Quick Response Code:	Website: www.saudijgastro.com
	DOI: 10.4103/sjg.SJG_426_17

adenomatous polyps and CRC due to its high rate of detection and ability to biopsy or resect some intestinal lesions.^[3] However, successful colonoscopy is highly dependent on satisfactory bowel cleansing. Inadequate bowel preparation may lead to a low diagnostic yield, an increased risk of complications, and the need for re-examination, thereby increasing pain and medical costs. Although several studies have been conducted to improve the quality of bowel preparation, the incidence of inadequate preparation is reportedly as high as 20–40%.^[4,5]

As in recent years, the population has aged, and the incidence of intestinal diseases in geriatric patients has increased, the majority of patients undergoing colonoscopy are elderly.^[6] Previous reports indicate that several factors are associated with inadequate colonoscopy bowel preparation including advanced age, male sex, education level, constipation, history of abdominal surgery, stroke, dementia, treatment with psychotropic drugs, and non-compliance with preparation instructions.^[7–9] However, few studies have investigated the rate of and risk factors for inadequate bowel preparation in the elderly. Additionally, existing studies were almost exclusively conducted in Western countries, and bowel preparation has rarely been investigated in the Chinese population.

Therefore, we conducted the current study to identify the status of bowel preparation and the risk factors for an inadequate preparation in elderly Chinese patients. We aimed to identify targeted interventions for bowel preparation optimization.

PATIENTS AND METHODS

Subjects

We prospectively enrolled consecutive outpatients over 60 years of age (the World Health Organization's definition of "elderly" in developing countries) who were scheduled for colonoscopy at the First Affiliated Hospital of Soochow University in China between November 2016 and April 2017. Exclusion criteria were intestinal obstruction and stenosis, a history of colon surgery or inflammatory bowel disease, a previous incomplete colonoscopy for reasons other than inadequate preparation, hospitalization during the study period, and the refusal to participate in the study. All patients provided written informed consent. Our institution's ethical committee approved the study.

Bowel preparation

We prescribed polyethylene glycol (PEG)-electrolyte solution dissolved in 3 L of water for bowel preparation, and patients

were instructed to drink 300 mL of PEG solution every 10 minutes until the entire 3 L volume was consumed.^[10] All patients drank the PEG solution between 7 and 9 a.m. on the day of the procedure and were required to walk at least 30 minutes during this period. The colonoscopies were performed between 1 and 4 p.m. Therefore, the time interval between the last dose of PEG and the start of the colonoscopy was less than seven hours. Although some studies have suggested that a split regimen is more appropriate for patients, the timing of the examination may affect the choice of preparation. Matro and Shnitser *et al.* found that patients who received morning-only PEG-electrolyte lavage solution (PEG-ELS) have a lower incidence of abdominal pain, superior sleep quality than split-dose PEG-ELS for afternoon colonoscopy.^[11] It is worth noting that two groups of patients are clinically equivalent with respect to cleansing efficacy and polyp detection. Therefore, we believe that a single dose is the best choice for patients undergoing an afternoon colonoscopy. Patients were instructed to eat a low-fiber diet beginning two days before the colonoscopy, and only clear liquids were permitted up to two hours before the procedure on the day of the colonoscopy.

Data collection

Based on a literature review and qualitative interviews, we designed a questionnaire to identify risk factors related to inadequate bowel preparation in elderly patients. The questionnaire included three parts and was administered before the procedure. The first part contained questions about demographic and clinical data, including the patient's age, sex, body mass index (BMI), history of abdominal surgery or colonoscopy, and comorbidities and the indication for colonoscopy.

The second part contained questions about the bowel preparation, including compliance with the instructions (dietary, PEG ingestion times, PEG dosages), the time spent walking during the preparation period, and side effects after taking PEG. Failing to follow the dietary restrictions or the walking instruction and consumption of less than 75% of the assigned preparation volume were considered non-compliance.^[12]

The third part of the questionnaire contained questions about predictors of bowel preparation adequacy determined immediately before colonoscopy, including bowel movement frequency after PEG consumption, the interval between starting PEG and the onset of bowel activity, and the characteristics of the last stool before the colonoscopy.

Assessment of bowel preparation quality

The quality of bowel preparation was evaluated per the Ottawa Bowel Preparation Scale (Ottawa Scale).^[13] The

scale categorizes the sufficiency of preparation in the right (cecum, ascending), mid (transverse, descending), and rectosigmoid colon segments. The score for each colon section ranges from 0–4 (0 = no fluid, 1 = minimal fluid and no suction required, 2 = suction required to expose the mucosa, 3 = washing and aspiration of solid stool, 4 = not washable). Additionally, the scale adds points for overall colonic fluid: a small amount (0 points), a medium amount (1 point), and a large amount (2 points). The scores of the three colon segments and the fluid quantity score are then summed, resulting in an overall score ranging from 0–14, where 14 indicates the worst quality of bowel preparation. An Ottawa Scale score (OBPS) <6 was considered adequate bowel preparation, and inadequate bowel preparation was defined as an OBPS \geq 6. All procedures were performed by three highly experienced colonoscopists (Wei Xia, Ling Li, Xiao Xu), each having performed more than 1,000 colonoscopies. Before beginning the study, all participating endoscopists were trained to master the Ottawa Scale scoring method.

Statistical analysis

All statistical analyses were performed using PASW Statistics for Windows, Version 18 (SPSS, Inc., Chicago, IL, US). Continuous data are expressed as means \pm standard deviation (SD) and categorical data are presented as frequencies or percentages (%). Categorical variables were compared using the χ^2 or Fishers exact probability test. Students *t*-test was used to compare continuous variables with normal distribution and the non-parametric Mann–Whitney *U* test for variables with a non-normal distribution, as appropriate. Both univariate and multivariate logistic regression analyses were performed to identify independent predictors for inadequate bowel preparation. Only variables that were statistically significant in the univariate analysis were assessed in the multivariate logistic regression modeling. All analyses were two-sided and *P* values <0.05 were considered statistically significant. The results are expressed as odds ratios (OR) with 95% confidence intervals (CI).

RESULTS

Baseline characteristics

During the study period, 1025 subjects underwent colonoscopy. We excluded 785 for the following reasons: age <60 years ($n = 550$), hospitalized status ($n = 205$), incomplete colonoscopy for reasons other than inadequate preparation ($n = 15$), prior colon resection ($n = 10$), and inflammatory bowel disease ($n = 5$). The remaining 240 subjects were analyzed [Figure 1]. The mean patient age was 67.21 ± 5.24 years and 116 (48.3%) were male.

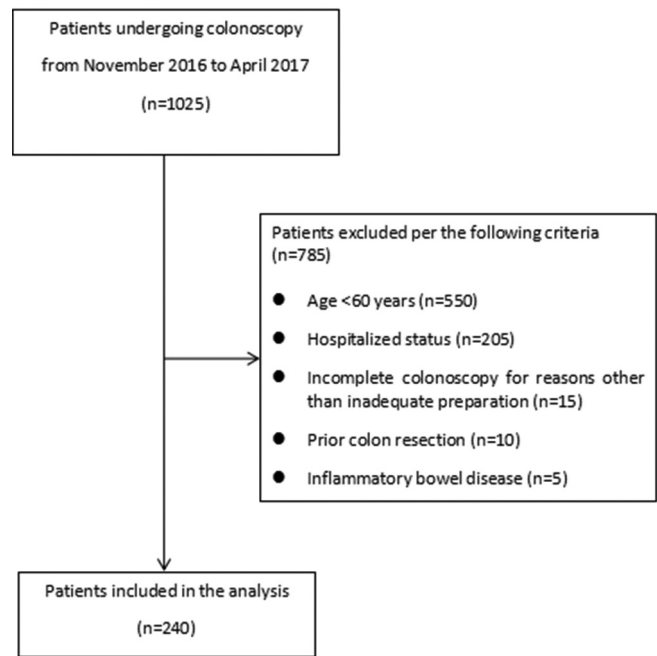


Figure 1: Study flow diagram

The average BMI was 22.94 ± 3.09 kg/m², and 79 (32.9%) had a secondary education or above. Ninety-three patients (38.8%) had a history of abdominal surgery, 15 (6.3%) had a family history of CRC in a first-degree relative and 95 (39.6%) had undergone colonoscopy before. Comorbid diseases included hypertension ($n = 88$, 36.7%), diabetes mellitus ($n = 41$, 17.1%), constipation ($n = 60$, 25.0%), previous stroke ($n = 15$, 6.3%), and liver cirrhosis ($n = 16$, 6.7%). The most common indication for colonoscopy was abdominal pain ($n = 85$, 35.4%) followed by constipation ($n = 60$, 25.0%), diarrhea ($n = 50$, 20.8%), hematochezia ($n = 31$, 12.9%), follow-up examination after polypectomy ($n = 26$, 10.8%), and routine health checkup ($n = 13$, 5.4%). Other indications comprised 4.2%. The average waiting period for a colonoscopy appointment was 9.26 ± 6.39 days [Table 1].

Univariate analysis: Risk factors for inadequate bowel preparation

Adequate and inadequate bowel preparation occurred in 157 (65.4%) and 83 (34.6%) patients, respectively. Eleven categorical and six continuous variables were included in the univariate analysis. Differences between patients with adequate and inadequate bowel preparations are presented in Tables 2 and 3. Patient's BMI; sex; education level; family history of colon cancer; history of colonoscopy; comorbid hypertension, diabetes mellitus, stroke, or liver cirrhosis; waiting period for a colonoscopy appointment; side effects after taking PEG; and the number of previous colonoscopies were not associated with inadequate bowel preparation ($P > 0.05$). Age ($P = 0.032$), a history

Table 1: Baseline characteristics of the study patients

	Study Patients (n=240)
Age (mean±SD, years)	67.21±5.24
Gender (Male/Female)	116/124
Body mass index (kg/m ²)	22.94±3.09
Education	
Illiteracy or primary school	161 (67.1)
Middle school or college	79 (32.9)
Indication for colonoscopy	
Hematochezia	31 (12.9)
Diarrhea	50 (20.8)
Abdominal pain	85 (35.4)
Constipation	60 (25.0)
Follow-up examination after polypectomy	26 (10.8)
Routine health checkup	13 (5.4)
Other	10 (4.2)
History of abdominal surgery	93 (38.8)
Family history of colon cancer	15 (6.3)
History of colonoscopy	95 (39.6)
Chronic comorbid disease	
Hypertension	88 (36.7)
Diabetes	41 (17.1)
Stroke	15 (6.3)
Liver cirrhosis	16 (6.7)
Constipation	60 (25.0)
Colonoscopy appointment waiting time (d)	9.26±6.39

SD: Standard deviation

Table 2: Univariate analysis of the factors (categorical variables) affecting bowel preparation in elderly patients

	Adequate Preparation (n=157)	Inadequate Preparation (n=83)	P
Gender			
Male	73	43	0.434
Female	84	40	
Education			
Illiteracy or primary school	101	60	0.212
Middle school or college	56	23	
History of abdominal surgery	45	48	0.000*
Family history of colon cancer	10	5	0.916
History of colonoscopy	68	27	0.104
Chronic comorbid disease			
Hypertension	52	36	0.117
Diabetes	22	19	0.082
Stroke	7	8	0.115
Liver cirrhosis	8	8	0.180
Constipation	23	37	0.000*
Non-compliance with dietary instructions	38	40	0.000*
Non-compliance with PEG dosage	12	20	0.000*
Walking time during medication <30 min	46	47	0.000*
Side effects after PEG ingestion	76	42	0.746
Characteristics of last stool			
Clear and watery	150	61	0.000*
Liquid with residue or Semisolid	7	22	

*Statistically significant difference

of abdominal surgery ($P = 0.000$), comorbid chronic constipation ($P = 0.000$), non-compliance with dietary instructions ($P = 0.000$), non-compliance with PEG

dosage ($P = 0.000$), walking <30 minutes during the preparation process ($P = 0.000$), bowel movement frequency after PEG ingestion ($P = 0.042$), the interval between starting PEG and the onset of bowel activity ($P = 0.000$), and the characteristics of the last stool ($P = 0.000$) were significantly associated with inadequate bowel preparation.

Multivariate analysis: Risk factors for inadequate bowel preparation

Based on the results of our univariate analysis, we conducted multivariate logistic regression analyses [Table 4]. A history of abdominal surgery (OR, 2.617; CI, 1.324–5.174; $P = 0.006$), chronic constipation (OR, 3.307; CI, 1.551–7.054; $P = 0.002$), non-compliance with dietary instructions (OR, 2.239; CI, 1.122–4.471; $P = 0.022$), non-compliance with PEG dosage (OR, 4.576; CI, 1.855–11.287; $P = 0.001$), walking <30 minutes during preparation (OR, 2.474; CI, 1.261–4.855; $P = 0.008$), interval between PEG ingestion and the onset of bowel activity (OR, 1.025; CI, 1.010–1.040; $P = 0.001$), and a last stool that was not clear and watery (OR, 4.191; CI, 1.529–11.485; $P = 0.005$) were independent risk factors for an inadequate bowel preparation.

DISCUSSION

We performed a prospective observational study to evaluate the incidence of and risk factors for poor pre-colonoscopy bowel preparation in Chinese outpatients over 60 years of age. The rate of inadequate bowel preparation was 34.6%, which is higher than the previously reported rate of approximately 30% in patients taking PEG-ELS for bowel preparation.^[14] This discrepancy in results may be because we enrolled only elderly patients while other studies had no patient age requirement. Many studies have confirmed that age ≥ 60 years is an important predictor of inadequate bowel preparation.^[14,15] This may be due to the weaker colonic motility in elderly patients. Further, patients in this population are likely to have chronic comorbid diseases and take multiple medications, which may increase the risk of inadequate bowel preparation. Additionally, most hospitals in China use 2–3 L PEG-ELS for bowel preparation,^[10] while western countries routinely recommend 4 L PEG-ELS or 2 L PEG-ELS + bisacodyl/vitamin C orally for bowel cleansing before colonoscopy.^[16,17] This difference in preparation regimen may also explain the greater incidence of inadequate bowel preparation in our study compared to others.

Adequate bowel preparation is a necessary condition for a successful colonoscopy. The ability to visualize the entire mucosal surface not only improves the rates of

Table 3: Univariate analysis of the factors (continuous variables) affecting bowel preparation in elderly patients

	Adequate Preparation (n=157)	Inadequate Preparation (n=83)	P
Age (mean±SD, years)	66.68±4.95	68.20±5.65	0.032*
Body mass index (kg/m ²)	22.85±3.09	23.11±3.11	0.550
Colonoscopy appointment waiting time (d)	9.04±6.62	9.67±5.96	0.464
Number of previous colonoscopies	0.69±1.07	0.54±0.97	0.300
Bowel movement frequency after PEG	8.54±2.84	7.75±2.92	0.042*
Interval between beginning PEG and the onset of bowel activity (min)	30.38±20.04	44.34±28.91	0.000*

*Statistically significant difference

Table 4: Binary logistic regression analysis of independent risk factors for inadequate bowel preparation in elderly patients

Variables	Adjusted OR	95% CI	P
History of abdominal surgery	2.617	1.324-5.174	0.006
Chronic constipation	3.307	1.551-7.054	0.002
Non-compliance with dietary instructions	2.239	1.122-4.471	0.022
Non-compliance with PEG dosage	4.576	1.855-11.287	0.001
Walking time during medication <30 min	2.474	1.261-4.855	0.008
Interval between the start of PEG and the onset of bowel activity (min)	1.025	1.010-1.040	0.001
Last stool was not clear and watery	4.191	1.529-11.485	0.005

OR: Odds ratio; CI: Confidence interval

cecal intubation and polyp detection but also shortens the procedure time, thus optimizing procedural efficiency.^[18] Therefore, it is important to identify the risk factors for inadequate bowel preparation. Although there have been some related studies, few have focused on the status of colonic cleansing in elderly patients or the factors that influence preparation outcome in this population. Bowel preparation in elderly patients requires further investigation.

We analyzed the risk factors for inadequate bowel preparation according to the Ottawa Scale and found that previous abdominal surgery was significantly associated with a poor preparation. Chung and Han *et al.* demonstrated that a history of abdominal surgery was an independent predictor for inadequate bowel preparation,^[14] which is consistent with our findings. This association may be because patients with a history of abdominal surgery are prone to intestinal adhesions that adversely affect intestinal emptying and, thereby, reduce the efficacy of bowel preparation. On the other hand, Cheng and Chiu *et al.* found that a history of abdominal surgery is not a risk factor for inadequate bowel preparation.^[19] However, the proportion of patients with a history of abdominal surgery in their study was small,

which may have caused this difference in results. We also found that elderly patients with chronic constipation had a higher risk of inadequate bowel preparation than those with no history of constipation, which was similarly reported by Fang *et al.*^[20] This may be attributed to the diminished intestinal motility in elderly patients that, in combination with chronic constipation, could lead to an intestinal emptying disorder and a large amount of residual stool in the bowel after the preparation.

The results of our study suggest that the volume of PEG ingested, compliance with dietary instructions, and the amount of time spent walking during the preparation process were three behavioral factors significantly associated with colonic cleanliness. Many studies have confirmed that adherence to a low residue diet is closely related to a good bowel preparation,^[21] and the recent guidelines from the European Society of Gastrointestinal Endoscopy^[16] also recommend a low-fiber diet on the day preceding colonoscopy. Seo *et al.* conducted a multivariate analysis showing that patients who do not take the entire preparation dose are more likely to have inadequate bowel preparation (OR, 4.34; CI, 1.08–16.66).^[22] Recently, several studies have confirmed that complete preparation is an important factor for a satisfactory bowel preparation,^[9,20] and a similar conclusion may be drawn from our study. Therefore, future studies to determine methods for ensuring that patients complete the preparation medication are worthwhile. Additionally, we found a correlation between the amount of time spent walking during the process of preparation and colonic cleanliness. To our knowledge, this is the first report demonstrating that a walking time during the PEG ingestion period <30 minutes may be a surrogate for bowel preparation failure. A possible mechanism to explain this finding is that prolonged walking promotes digestive gland secretion and gastrointestinal motility, thereby increasing the rate of gastrointestinal tract emptying and improving colonic cleanliness.^[23]

Kim *et al.* found that patients who report that their last stool is semisolid are likely to have a poor bowel preparation, consistent with our findings.^[24] We also found that the time interval between beginning PEG ingestion and the onset of bowel activity can predict the quality of bowel preparation, and this result confirms that of Papastergiou *et al.*^[25] In other words, the longer the interval, the slower the movement through the patient's gastrointestinal tract, suggesting that the patient may present with inadequate bowel preparation.

Some limitations of our study need to be considered when interpreting the results. First, this was a single-center study

at an academic medical center, and our results may not be generalizable, although our findings are consistent with those of previous reports. Second, we did not analyze the relationship between living conditions and colonic cleanliness in elderly patients, and family involvement in bowel preparation may promote compliance with the relevant requirements in elderly patients preparing for a colonoscopy. Last, some information about bowel preparation (e.g. bowel movement frequency after PEG) was self-reported, so recall error is unavoidable.

CONCLUSION

To the best of our knowledge, we are the first to investigate the status of bowel preparation in elderly patients and analyze factors associated with an inadequate preparation. In this study, 34.6% of our elderly Chinese patients had a poor bowel preparation at the time of colonoscopy, and there were seven independent risk factors for bowel preparation failure. Therefore, elderly patients with these risk factors should be identified early and managed with targeted interventions to effectively reduce the rate of inadequate bowel preparation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Lieberman DA, Rex DK, Winawer SJ, Giardiello FM, Johnson DA, Levin TR. Guidelines for colonoscopy surveillance after screening and polypectomy: A consensus update by the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology* 2012;143:844-57.
- Chen W, Zheng R, Baade PD, Zhang S, Zeng H, Jemal A, et al. Cancer statistics in China, 2015. *CA Cancer J Clin* 2016;66:115-32.
- Schoen RE, Pinsky PF, Weissfeld JL, Fouad MN, Riley TL, Gohagan JK, et al. Colorectal-cancer incidence and mortality with screening flexible sigmoidoscopy. *N Engl J Med* 2012;366:2345-57.
- Chan WK, Saravanan A, Manikam J, Goh KL, Mahadeva S. Appointment waiting times and education level influence the quality of bowel preparation in adult patients undergoing colonoscopy. *BMC Gastroenterol* 2011;11:86.
- Appannagari A, Mangla S, Liao C, Reddy KG, Kupfer SS. Risk factors for inadequate colonoscopy bowel preparations in African Americans and whites at an urban medical center. *South Med J* 2014;107:220-4.
- Ho SB, Hovsepian R, Gupta S. Optimal bowel cleansing for colonoscopy in the elderly patient. *Drugs Aging* 2014;34:163-72.
- Nguyen DL, Wieland M. Risk factors predictive of poor quality preparation during average risk colonoscopy screening: The importance of health literacy. *J Gastrointest Liver Dis* 2010;19:369-72.
- Bhanthumkomol P, Siramolpiwat S, Vilaichone RK. Incidence and predictors of inadequate bowel preparation before elective colonoscopy in Thai patients. *Asian Pac J Cancer Prev* 2014;15:10763-8.
- Hautefeuille G, Lapuelle J, Chaussade S, Ponchon T, Molard BR, Laugeir R, et al. Factors related to bowel cleansing failure before colonoscopy: Results of the PACOME study. *United European Gastroenterol J* 2014;2:22-9.
- Qin Y, Liu W, Lin S, Li X. Effects of first-dose volume and exercise on the efficacy and tolerability of bowel preparations for colonoscopy in Chinese people. *Ther Clin Risk Manag* 2016;12:613-6.
- Matro R, Shnitser A, Spodik M, Daskalakis C, Katz L, Murtha A, et al. Efficacy of morning-only compared with split-dose polyethylene glycol electrolyte solution for afternoon colonoscopy: A randomized controlled single-blind study. *Am J Gastroenterol* 2010;105:1954-61.
- Zhang S, Li M, Zhao Y, Lv T, Shu Q, Zhi F, et al. 3-L split-dose is superior to 2-L polyethylene glycol in bowel cleansing in Chinese population: A multicenter randomized, controlled trial. *Medicine (Baltimore)* 2015;94:e472.
- Rostom A, Jolicoeur E. Validation of a new scale for the assessment of bowel preparation quality. *Gastrointest Endosc* 2004;59:482-6.
- Chung YW, Han DS, Park KH, Kim KO, Park CH, Kim JH, et al. Patient factors predictive of inadequate bowel preparation using polyethylene glycol: A prospective study in Korea. *J Clin Gastroenterol* 2009;43:448-52.
- Wong MC, Ching JY, Chan VC, Tang RS, Lam TY, Luk Ak, et al. Determinants of bowel preparation quality and its association with adenoma detection: A prospective colonoscopy study. *Medicine (Baltimore)* 2016;95:e2251.
- Hassan C, Bretthauer M, Kaminski MF, Polkowski M, Green S, Omar M, et al. Bowel preparation for colonoscopy: European Society of Gastrointestinal Endoscopy (ESGE) guideline. *Endoscopy* 2013;45:142-50.
- Johnson DA, Barkun AN, Cohen LB, Martel M, Robertson DJ, Levin TR, et al. Optimizing adequacy of bowel cleansing for colonoscopy: Recommendations from the US multi-society task force on colorectal cancer. *Gastroenterology* 2014;147:903-24.
- van Doorn SC, Dekker E. Colonoscopy quality begins with a clean colon. *Endoscopy* 2012;44:639-40.
- Cheng RW, Chiu YC, Wu KL, Rayner CK, Tai WC, Liang CM, et al. Predictive factors for inadequate colon preparation before colonoscopy. *Tech Coloproctol* 2015;19:111-5.
- Fang J, Fu HY, Ma D, Wang D, Wang YF, Li ZS, et al. Constipation, fiber intake and non-compliance contribute to inadequate colonoscopy bowel preparation: A prospective cohort study. *J Dig Dis* 2016;17:458-63.
- Wu KL, Rayner CK, Chuah SK, Chiu KW, Lu CC, Chiu YC. Impact of low-residue diet on bowel preparation for colonoscopy. *Dis Colon Rectum* 2011;54:107-12.
- Seo EH, Kim TO, Park MJ, Park J, Park SH, Moon YS, et al. Optimal preparation-to-colonoscopy interval in split-dose PEG bowel preparation determines satisfactory bowel preparation quality: An observational prospective study. *Gastrointest Endosc* 2012;75:583-90.
- Kim HS, Park DH, Kim JW, Jee MG, Baik SK, Lee DK, et al. Effectiveness of walking exercise as a bowel preparation for colonoscopy: A randomized controlled trial. *Am J Gastroenterol* 2005;100:1964-9.
- Kim HG, Jeon SR, Kim MY, Lee TH, Kim JO, Lee JS, et al. How to predict adequate bowel preparation before colonoscopy using conventional polyethylene glycol: Prospective observational study based on survey. *Gastrointest Endosc* 2015;27:87-94.
- Papastergiou V, Papasavvas S, Mathou N, Giannakopoulos A, Evgenidi A, Paraskeva KD, et al. A delayed onset of bowel activity after the start of conventional polyethylene glycol predicts inadequate colon cleansing before colonoscopy: A prospective observational study. *United European Gastroenterol J* 2016;4:199-206.