

Importance of the Time Interval between Bowel Preparation and Colonoscopy in Determining the Quality of Bowel Preparation for Full-Dose Polyethylene Glycol Preparation

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Background/Aims: The quality of bowel preparation (QBP) is the important factor in performing a successful colonoscopy. Several factors influencing QBP have been reported; however, some factors, such as the optimal preparation-to-colonoscopy time interval, remain controversial. This study aimed to determine the factors influencing QBP and the optimal time interval for full-dose polyethylene glycol (PEG) preparation. **Methods:** A total of 165 patients who underwent colonoscopy from June 2012 to August 2012 were prospectively evaluated. The QBP was assessed using the Ottawa Bowel Preparation Scale (Ottawa) score according to several factors influencing the QBP were analyzed. **Results:** Colonoscopies with a time interval of 5 to 6 hours had the best Ottawa score in all parts of the colon. Patients with time intervals of 6 hours or less had the better QBP than those with time intervals of more than 6 hours ($p=0.046$). In the multivariate analysis, the time interval (odds ratio, 1.897; 95% confidence interval, 1.006 to 3.577; $p=0.048$) was the only significant contributor to a satisfactory bowel preparation. **Conclusions:** The optimal time was 5 to 6 hours for the full-dose PEG method, and the time interval was the only significant contributor to a satisfactory bowel preparation. (*Gut Liver* 2014;8:625-631)

Key Words: Quality of bowel preparation; Colonoscopy; Time interval

INTRODUCTION

Colonoscopy is considered the gold standard in screening and

surveillance of colorectal cancer because colonoscopy clearly detects abnormal lesions and allows simultaneous biopsy or resection. However, the detection rate of colon lesions through colonoscopy is affected by the quality of bowel preparation (QBP).^{1,2} According to previous studies, about 20% patients were found to have inadequate bowel preparation at the time of colonoscopy.^{3,4} Inadequate bowel preparation may lead to a decreased cecal intubation rate, increased risk of missing lesions, increased patient discomfort, higher risk of complications, and prolonged procedure time.⁵

Several factors including older age, male sex, diabetes, constipation, history of abdominal or gynecologic surgery, compliance with preparation instructions, and bowel preparation type were reported as predictors for inadequate bowel preparation for colonoscopy.^{6,7} It was also showed that colonoscopy performed in the afternoon had more frequent rates of inadequate bowel preparation and incomplete colonoscopy than in the morning^{8,9} and the time interval between the last polyethylene glycol (PEG) intake and the start of colonoscopy were more important than the timing of colonoscopy in determining QBP.^{10,11}

A recent study reported that the optimal time interval between the last PEG intake and the start of colonoscopy was 3 to 5 hours for split-dose PEG method¹² but studies for the optimal time interval for full-dose PEG method are limited.¹¹ Although split-dose PEG method is better than full-dose PEG method on bowel cleansing, patient tolerability and safety,¹³ a number of medical centers are still using full-dose PEG method because of similar results of bowel cleansing compared with split-dose PEG method and mainly afternoon examination.

The aim of this study was to determine the optimal time in-

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terval between the last PEG intake and the start of colonoscopy, and the other factors affecting satisfactory bowel preparation for full-dose PEG preparation.

MATERIALS AND METHODS

1. Subjects

We prospectively enrolled consecutive 259 outpatients aged between 18 and 80 years who were scheduled for elective colonoscopy at the Pusan National University Yangsan Hospital between June 2012 and August 2012. Exclusion criteria were as follow: pregnancy, breastfeeding, history of surgical large-bowel resection (including hemicolectomy) except appendectomy, wedge resection, inflammatory bowel disease, drug addiction or major psychiatric illness, allergy to PEG, incomplete intake of PEG, therapeutic procedure (hemostasis, endoscopic mucosal resection, endoscopic submucosal dissection), and over 12 hours on time interval. Finally, 165 patients were enrolled. This study was approved by the Institutional Review Board of Pusan National University Yangsan Hospital.

2. Bowel preparation and colonoscopic procedure

All patients were instructed to avoid eating a high-fiber diet for 2 days before starting the bowel preparation and to drink only liquids for the entire day prior to colonoscopy. All patients were instructed to drink 4 L of PEG solution (Taejoon Pharm. Inc., Seoul, Korea; 236 g PEG, 2.97 g KCl, 6.74 g NaHCO₃, 5.86 g NaCl, 22.74 g Na₂SO₄) over a period of 2 hours starting either at 11:00 PM the previous day (morning session) or at 6:00 AM (afternoon session) on the day of the colonoscopy.

Morning sessions and afternoon sessions were defined as colonoscopic procedures starting between 8:30 AM and 12:30 PM and at 1:30 PM and thereafter, respectively.

All colonoscopies were performed by three experienced colonoscopists with a mean experience of 7 years (range, 4 to 10 years). Each of the colonoscopists contributed equally to morning and afternoon sessions.

3. Data collection

All patients were provided with questionnaires to assess last PEG intake time and amount of PEG solution taken, avoiding eating a high-fiber diet before colonoscopy scheduling. We enrolled patients who drank whole volume of PEG solution. For each patient, the following data were collected: sex, age, body mass index (BMI), previous colorectal operation, previous obstetrics or gynecology operation, other medical comorbidities including diabetes, hypertension and liver cirrhosis, and constipation. Constipation was defined as fewer than three bowel movements per week regardless of drug intake.

4. Evaluation of bowel preparation

After each procedure, the colonoscopists scored the QBP us-

ing Ottawa Bowel Preparation Scale (Ottawa) score. The cleanliness of each colonic segment, divided into the right colon (cecum and ascending colon), the mid colon (transverse and descending colon) and rectosigmoid colon was rated from 0 to 4. The worst cleanliness score was 4 points. The volume of colonic fluid was rated from 0 to 2 for the entire colon. The maximum volume of fluid score was 2 points. A summary score was then obtained from the individual parameters. We determined that Ottawa score of 6 or less was acceptable for satisfactory preparation.

Before applying the bowel preparation scales, the participating endoscopists undertook a calibration exercise for achieving excellent interobserver agreement (intraclass correlation coefficient [ICC] >0.8). The calibration exercise was carried out using 10 testing colonoscopy images. If the ICC of the interobserver agreement failed to reach 0.8, then a calibration exercise with discussions among the endoscopists was repeated. After 2 weeks of calibration exercises, the interobserver agreement was remeasured using 10 different testing colonoscopy images. This calibration exercise was repeated until excellent interobserver agreement was achieved among the endoscopists.

5. Statistical analyses

Statistical analyses were performed using PASW Statistics version 18 for Windows (SPSS Inc., Chicago, IL, USA). Continuous variables were reported as mean (SD) and categorical variables as percentages. Two-sided t-tests were used to compare the means of the continuous variables in the two groups, and chi-square tests were used to compare the categorical variables. The factors statistically significant ($p < 0.05$) in univariate analysis were included in multivariate analysis. Forward stepwise multivariate logistic regression analysis was used to assess factors affecting bowel preparation quality. $p < 0.05$ was considered to be statistically significant.

RESULTS

Among 259 patients, 165 patients were enrolled except three patients under 18 years, 22 patients with history of surgical large-bowel resection, 14 patients with incomplete intake of PEG because of nausea, vomiting, and abdominal distension, 42 patients who underwent therapeutic procedure, 13 patients with longer than 12 hours of time interval. A total of 165 consecutive patients referred for colonoscopy were enrolled in the study (Table 1). Of them, there were 108 men (65.5%) and 57 women (34.5%), with a mean age of 53.92 years (range, 18 to 82 years). Thirty-nine patients (23.6%) underwent colonoscopy in the morning session and 126 patients (76.4%) underwent colonoscopy in the afternoon session. Thirteen patients (33.3%) in the morning session patient group and 59 patients (46.8%) in the afternoon session patient group had satisfactory bowel preparation. There is no statistical difference between the groups ($p = 0.138$). Mean BMI was 24.20 kg/m² (range, 16.6 to 38.0 kg/

m²). Seven patients (4.2%) had previously undergone colorectal operation, and 12 patients (7.3%) had undergone obstetrics or gynecology operation. Sixteen patients (9.7%) had diabetes mellitus, 39 patients (23.6%) had hypertension, six patients (3.6%) had liver cirrhosis, and 28 patients (17.0%) had constipation. One hundred twenty-eight patients (77.6%) underwent colonoscopy for regular checkup. Nineteen patients (11.5%) underwent colonoscopy for abdominal pain, diarrhea. Eighteen patients (10.9%) underwent colonoscopy for constipation. Ten patients among 128 patients for routine checkup (7.8%) had constipation. Mean time interval between completion of the last PEG

intake and the start of colonoscopy was 376.44 minutes (range, 39 to 720 minutes). Mean Ottawa score was 7.2 points (range, 3 to 13 points).

1. The relationship between time interval and Ottawa score

The Ottawa score (mean±SD) for the right, mid, rectosigmoid colon and fluid volume are 3.04±0.727, 1.69±0.853, 1.28±0.590, and 1.19±0.712, respectively. The right colon score was rated higher than other colon segments, indicating that bowel cleansing is usually most difficult in this segment.

We evaluated whether there were any significant differences in Ottawa score for the whole colon, each segment, and fluid quantity according to the time interval between the last PEG intake and the start of colonoscopy. Fig. 1 presents the relationships between the mean total Ottawa score and the each time interval of preparation-to-colonoscopy. Colonoscopies with time interval of 5- to 6-hour had the best bowel preparation quality (mean±SD, 6.35±0.263) and best Ottawa score on each segment and fluid amount. Time interval for the best cleansing and the least fluid amount in right colon was 5 to 6 hours. The total Ottawa score for the time interval of 5- to 6-hour did not statistically differ compared with 4- to 7-hour. On the other hand, the time interval under 3 hours and over 8 hours were statistically more unsatisfactory bowel cleansing compared with the time interval of 5- to 6-hour (p=0.038, p<0.01) (Fig. 1). In afternoon session subgroup analysis, time interval for the best cleansing and the least fluid amount in right colon was also 5 to 6 hours (Fig. 2).

2. Factors affecting bowel preparation quality

We evaluated the other factors that might influence QBP except the time interval between the last PEG intake and the start of colonoscopy. We determined that the Ottawa score of

Table 1. Baseline Patient Characteristics (N=165)

Characteristic	Value
Age at time of colonoscopy, yr	53.92±11.48 (18-82)
Female sex	57 (34.5)
Morning session	39 (23.6)
Body mass index, kg/m ²	24.20±3.07 (16.6-38.0)
Previous colorectal operation	7 (4.2)
Previous obstetrics and gynecology operation	12 (7.3)
History of comorbid condition	82 (49.7)
Diabetes mellitus	16 (9.7)
Hypertension	39 (23.6)
Liver cirrhosis	6 (3.6)
Constipation	28 (17.0)
Time interval between PEG intake and colonoscopy, min	376.44±144.58 (39-720)
Ottawa Bowel Preparation Scale score	7.20±2.12 (1-13)

Data are presented as mean±SD (range) or number (%). PEG, polyethylene glycol.

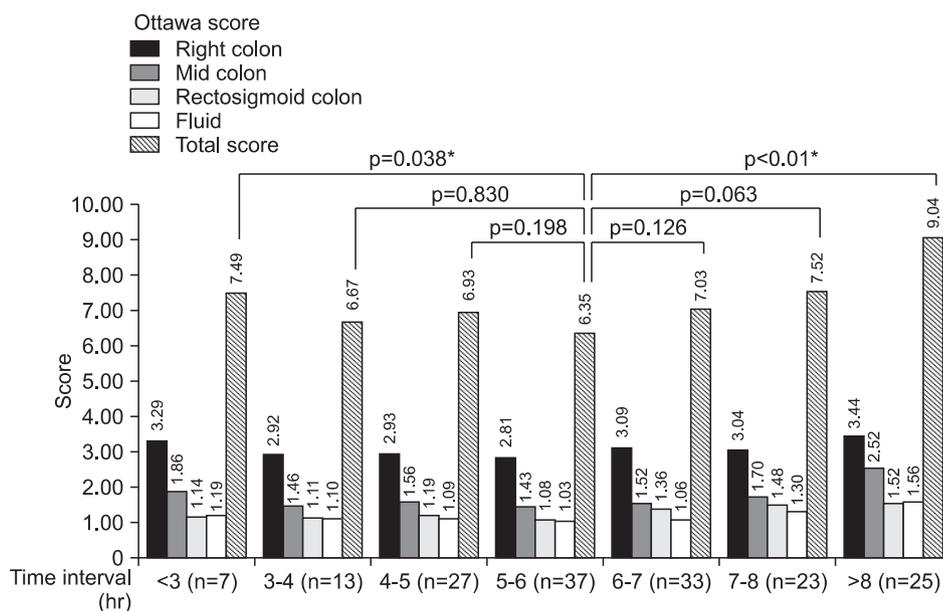


Fig. 1. The relationship between the time interval and Ottawa Bowel Preparation Scale score. *p<0.05.

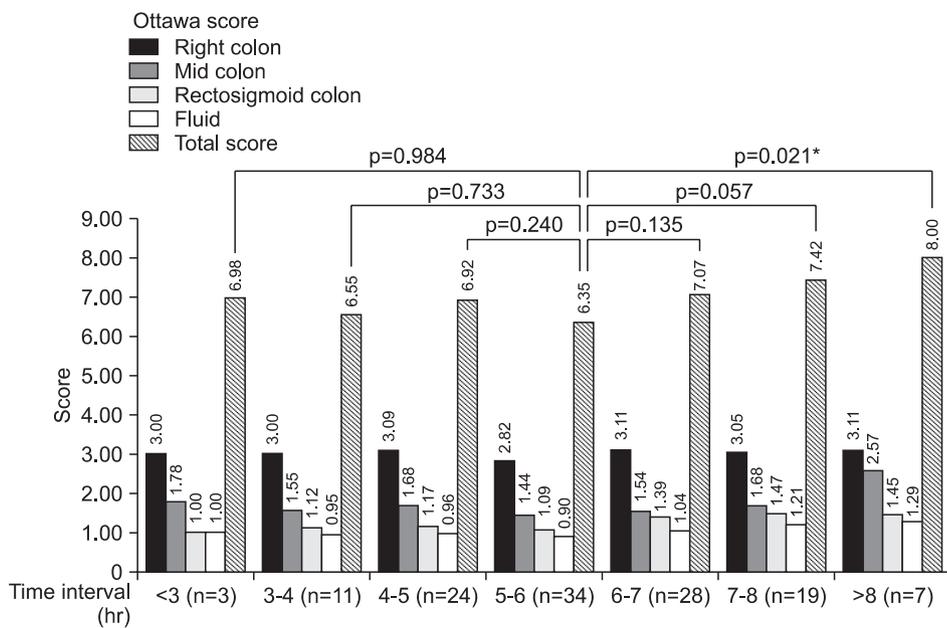


Fig. 2. The relationship between the time interval and Ottawa Bowel Preparation Scale score for an afternoon session. *p<0.05.

Table 2. Univariate Analysis of Factors Associated with a Satisfactory Bowel Preparation

	Satisfactory preparation (Ottawa score 0–6, n=72)	Unsatisfactory preparation (Ottawa score 7–14, n=93)	p-value
Male sex	44 (61.1)	64 (68.8)	0.302
Age, yr	55.03±10.90	53.05±11.90	0.275
Body mass index, kg/m ²	23.85±3.08	24.47±3.06	0.202
Hypertension	17 (23.6)	22 (23.7)	0.995
Diabetes	5 (6.9)	11 (11.8)	0.293
Liver cirrhosis	2 (2.8)	4 (4.3)	0.604
Previous colorectal operation	2 (2.8)	5 (5.4)	0.411
Previous obstetrics and gynecologic operation	6 (8.3)	6 (6.5)	0.644
Constipation	12 (16.7)	16 (17.2)	0.823
Morning session	13 (18.1)	26 (28.0)	0.138
Time interval of 3 to 6 hours	41 (56.9)	36 (38.7)	0.027

Data are presented as mean±SD or number (%).

6 or less was acceptable for detecting lesions during colonoscopy because we observed that QBP with scores between 0 and 6 had liquid stool in any colon segment. So we categorized the patients into a satisfactory group (Ottawa score 0 to 6) and an unsatisfactory group (Ottawa score 7 to 14) for analyses. In univariate analysis for satisfactory bowel preparation, only the time interval of 3- to 6-hour significantly influenced QBP (p=0.027). Other factors including sex, age, BMI, presence of hypertension, diabetes mellitus, liver cirrhosis, constipation, previous colorectal operation, previous obstetrics and gynecologic operation did not influence QBP (Table 2). In afternoon session subgroup analysis, time interval of 3- to 6-hour also influenced QBP (p=0.019) but other factors did not (Table 3). In multivariate analysis, we included sex and age to correct for basic demo-

graphic factor. As a results, the time interval of 3- to 6-hour (odds ratio, 2.085; 95% confidence interval, 1.087 to 4.001; p=0.027) was only significant contributor to satisfactory bowel preparation in multivariate analysis (Table 4).

DISCUSSION

Performing colonoscopy with better bowel cleansing improves detection of colonic lesions, shortens total procedural time and results in lower rates of complications. According to previous studies, about 20% patients were found to have inadequate bowel preparation at the time of colonoscopy.^{3,4} Recent studies showed that inadequate bowel preparation for colonoscopy was predicted by several factors, such as older age, female

Table 3. Univariate Analysis of Factors Associated with a Satisfactory Bowel Preparation for an Afternoon Session

	Satisfactory preparation (Ottawa score 0–6, n=72)	Unsatisfactory preparation (Ottawa score 7–14, n=93)	p-value
Male sex	36 (61.0)	43 (64.2)	0.714
Age, yr	56.34±10.31	55.00±12.55	0.517
Body mass index, kg/m ²	23.63±3.13	24.53±3.09	0.108
Hypertension	15 (25.4)	20 (29.9)	0.58
Diabetes	5 (8.5)	7 (10.4)	0.707
Liver cirrhosis	2 (3.4)	4 (6.0)	0.497
Previous colorectal operation	1 (1.7)	5 (7.5)	0.129
Previous obstetrics and gynecologic operation	5 (8.5)	6 (9.0)	0.924
constipation	15 (25.4)	16 (23.9)	0.841
Time interval of 3 to 6 hours	39 (66.1)	30 (44.7)	0.019

Data are presented as mean±SD or number (%).

Table 4. Multivariate Analysis of Factors Associated with a Satisfactory Bowel Preparation

	Adjusted OR	95% CI	p-value
Male sex	0.673	0.348–1.302	0.240
Age, yr	0.988	0.961–1.016	0.385
Time interval of 3 to 6 hours	2.085	1.087–4.001	0.027

OR, odds ratio; CI, confidence interval.

sex, diabetes, constipation, history of abdominal or gynecologic surgery, compliance with preparation instructions, and bowel preparation type.^{6,7} For satisfactory bowel cleansing, we investigated how the time interval between completion of the last PEG intake and the start of colonoscopy influenced the QBP. In addition, other factors that might affect QBP were analyzed.

Complications of full-dose PEG methods are Mallory-Weiss tear, esophageal perforation, acute respiratory distress syndrome related to pulmonary edema, aspiration pneumonia, anaphylaxis, ileus, and bowel perforation. In our study, no complications of full-dose PEG methods occurred in enrolled patients. Limitation of full-dose PEG method was a poor compliance due to nausea, vomiting, and abdominal distension related to the salty taste, the smell from the sulfates and the large volume of fluids. But in our study, we used full dose method on the day before procedure in the hospitalized case the previous day for general health screening. Because we examined colonoscopy in the early morning, we cannot carry out bowel preparation on the day of the colonoscopy. Also, in the case of morning ultrasonography, we can't used full dose method on the day before procedure. For this reason, we enrolled 39 patients.

There are previous studies that time intervals influenced bowel cleansing. Church¹⁴ reported that bowel cleansing was worse in patients who had colonoscopy after 19 or more hours after the start of the bowel preparation compared to patients who had colonoscopy within 5 hours of the preparation. Yoon

*et al.*¹⁵ reported that group of more than 7 hours of elapsed time presented poor cleansing quality than others. Eun *et al.*¹¹ reported that patients with intervals of 4 hours or less between the end of PEG intake and the start of colonoscopy had a better QBP than those with intervals of more than 4 hours in full-dose PEG method. Seo *et al.*¹² reported that patients with time interval of 3- to 5-hour between the last dose of the agent and the start of colonoscopy have the best QBP in split-dose PEG method. We found that the time interval for the best quality was 5 to 6 hours throughout the whole colon, right colon, mid colon and rectosigmoid colon for full-dose PEG method, and colonoscopies performed within 3 to 6 hours on completion of the last PEG intake showed better QBP. We assume that this difference is most likely due to the difference in the patient groups or PEG intake methods and timing. In the study of Church,¹⁴ colonoscopy was performed in the morning only whereas in this study, subjects were divided into morning session and afternoon session. In the study of Eun *et al.*,¹¹ the patients received the PEG solution and colonoscopy on the same day. On the other hand, in our study, the patients who had colonoscopy in the morning took the PEG solution in the previous evening and the time interval between the completion of PEG solution and the start of colonoscopy was longer. In afternoon session subgroup analysis, optimal time interval differed by 1 to 2 hours compared to previous study. Although we cannot find the accurate cause of this difference, the proportion of patients with slow PEG intake (>2 hours) to the fast PEG intake (≤2 hours) may be the cause of the difference of the optimal time interval between two studies. While the study of Seo *et al.*¹² used split-dose PEG method, our study used full-dose PEG method. It is thought that the longer time interval for the best bowel cleansing in this study comparing to previous studies was due to the use of split-dose PEG method and the volume of colonic fluid.

When the last dose of a purgative is administered within 8 to 12 hours of a colonoscopy, stool is cleared from the colon, but

mucus and chime subsequently released from the small intestine may adhere to the cecum and right colon, making a thorough examination difficult.¹⁶ So the right side of the colon is particularly difficult for finding flat polyps because of concealment by opaque small-bowel effluent.¹⁴ In bowel preparation of colonoscopy, right colon cleansing is considered to be important because the cleansing can be difficult and polyps located in right colon may be easily missed. Hong *et al.*¹⁷ showed that risk of missed colon lesions was increased in patients with poor/inadequate bowel preparation compared to the patients with excellent bowel preparation. In our study, best right colon cleansing was performed colonoscopy with the time interval of 5- to 6-hour and the worse right colon cleansing was performed with the time interval of 3 or less hours and 8 or more hours.

In this study, we classified the QBP into a satisfactory group (Ottawa score 0 to 6) and an unsatisfactory group (Ottawa score 7 to 14) for a simple and clear analysis of the factors affecting QBP. In a study of Seo *et al.*,¹² authors determined that an Ottawa score of 5 or less was acceptable for detecting flat lesions during the colonoscopy. However, in this study, the QBP with Ottawa scores between 0 and 6 was sufficient for detecting lesions because we observed liquid stool or liquid only in all colon segments. Thus, the Ottawa score of 6 or less was determined as a satisfactory group. Multivariate analysis showed that the time interval of 6-hour or less was only significant contributor to satisfactory bowel preparation when correcting basic demographic factors including age and sex. But QBP was poor as time interval shortened within 3 hours or less. Because bowel fluid was much, Ottawa score was higher. So the time interval of 3- to 6-hour was important factor to determine satisfactory bowel preparation quality.

Several factors have been reported to predict inadequate bowel preparation for colonoscopy and include older age, female sex, diabetes, constipation, history of abdominal or gynecologic surgery, compliance with preparation instructions, and bowel preparation type.^{6,7} In our study, these factors were not significantly related with inadequate bowel preparation.

There are limitations to our study. First, our study was conducted by the prospective design but not randomized. Second, the sample size of this study was relatively small. Consequently, influential factors affecting QBP may not be sufficiently reflected.

In conclusion, we suggest that in full-dose PEG method, the optimal time interval between the last PEG intake and the start of colonoscopy was 5 to 6 hours for adequate QBP, and the time interval was only important factor to determine satisfactory bowel preparation quality. Persistent efforts to improve the QBP for colonoscopy are needed to increase the effectiveness of colonoscopy.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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