Multi-center study of residual gastric volume and bowel preparation after the usage of 1L and 2L polyethylene glycol in Korea

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Background: In colonoscopy, good bowel preparation is an important factor in determining the quality of colonoscopy. However, an increase in residual gastric volume (RGV) can lead to a higher risk of aspiration pneumonia. Therefore, the purpose of this study was to investigate the factors related to an increase in RGV with the usage of 1L polyethylene glycol (PEG).

Methods: We prospectively analyzed 268 patients who underwent both gastroscopy and colonoscopy at 2 hospitals from May to October 2021. Bowel preparation was performed using 1L in 127 patients (47.4%) and 2L PEG in 141 patients (52.6%). We investigated the time taken for bowel preparation solutions, the last water intake, total water intake, and RGV, and conducted a survey on taking compliance and satisfaction.

Results: The level of RGV was significantly increased in the 1L PEG group when compared to the 2L PEG group (1L, 52.26 ± 65.33 vs 2L, 23.55 ± 22.99; $P < .001$). There was no difference between the 2 groups in the degree of bowel preparation, but there were more bubbles formed in the 1L group (1L, 1.91 ± 2.74 vs 2L, 1.10 ± 2.02; $P = .007$). In the case of RGV ≥ 50 mL, in multivariate analysis, the risk was higher in water intake within 5 hours and the patients who think the dose is too high (all $P < .05$).

Conclusion: Therefore, since RGV is higher in 1L PEG than in 2L PEG, it is necessary to be careful not to take water for at least 5 hours before the test.

Abbreviations: BBPS = Boston bowel preparation scale, CIs = confidence intervals, mL = milliliter, ORs = odds ratios, PEG = polyethylene glycol, RGV = residual gastric volume, SD = standard deviation.

Keywords: 1L polyethylene glycol, Bowel preparation, residual gastric volume

1. Introduction

Colonoscopy is an important modality widely used in the diagnosis and treatment of colorectal disorders including colorectal cancer.[1] According to the 2020 report of global cancer statics GLOBOCAN, more than 1.9 million new cases of colorectal cancer (including anal) have occurred, and it is estimated that 935,000 people have died.[2] In addition, colorectal cancer still has the third highest prevalence among all cancers in Korea.[3] Therefore, early detection and removal of colorectal adenomatous polyps during colonoscopy is necessary for the prevention and treatment of colorectal cancer,[4] also diagnosing and treating various diseases of the colon through colonoscopy is an important purpose of the examination.[1]

For improving the quality of colonoscopy, proper bowel preparation is an essential condition.[5] According to the European Society of Gastrointestinal Endoscopy guideline in 2019, elective colonoscopy recommends performing a split-dose bowel preparation and completing the final preparation within 5 hours prior to colonoscopy.[6] Nevertheless, an important risk in colonoscopy with deep sedation is that the greater the residual gastric volume (RGV) during bowel preparation, the greater the risk of aspiration pneumonia.[5] The American Society of Anesthesiologists recommends that patients consume clear liquids up to 2 hours prior to administration of anesthesia.[7] However, there are still insufficient data on the clear time and risk factors for lowering the risk related to RGV. In particular, recently, low-volume PEG is being developed to increase patients' adherence to solution; hence, research on RGV in these concentrated solutions is necessary. Therefore, we aimed to investigate the effects of 1L polyethylene glycol (PEG) on RGV and its related risk factors compared to conventional 2L PEG.

2. Methods

2.1. Patients

Patients aged 19 years or older who underwent gastroscopy and colonoscopy together at Haeundae Paik Hospital and Busan Paik Hospital, Inje University, Busan, Korea from May to October 2021 were enrolled. The exclusion criteria were as follows: acute gastrointestinal bleeding, signs of gastrointestinal obstruction (gastric outlet or bowel obstruction), if serious cardiopulmonary disease is accompanied, if sedation endoscopy is not possible, pregnant or lactating, gastric surgery status, and the researcher judged that it was not appropriate. Following these criteria, 299 patients enrolled in this study. However, among them, 31 patients were excluded for the following reasons: patients who did not perform gastroscopy and colonoscopy on the same day (n = 4), patients who changed to another bowel preparation agent (n = 4), additional use of bowel preparation agent or very poor prep due to incomplete use (n = 4), test cancelation (n = 10), (v) GRV measurement failure (n = 1), unavailable data (n = 8) (Fig. 1). Finally, 268 patients were included in the study. This study was a multicenter, prospective, randomized study in which bowel preparation solutions were randomly selected. 127 patients used 1L PEG (Clenviewal, TaeJoon Pharmaceuticals, Seoul, Korea) and 141 patients had bowel preparations with 2L PEG (CoolPrep, TaeJoon Pharmaceuticals, Seoul, Korea).

The purpose and content of the study were detailed by the research staff at each hospital, and all participants provided written informed consent prior to enrollment. Clinical information such as age, gender, height, weight, body mass index, reason for colonoscopy, previous execution and accompanying underlying diseases were collected as baseline characteristics. This study was conducted under the ethical guidelines of the 1975 Declaration of Helsinki and approved by the institutional review board of each hospital.

2.2. Bowel preparation related factors

2.2.1. During bowel preparation
In order to analyze the factors related to taking the bowel preparation solution, the last taking time of bowel preparation, the last water intake time, amount of total water intake, and gastroscopy/colonoscopy examination time were investigated. In addition, the questionnaire was distributed in advance so that the accompanying symptoms that occurred while taking bowel preparation solutions could be written and guided, and they brought it with them on the day of the examination.

2.2.2. Bowel preparation score
The evaluation of bowel preparation was performed using the Boston Bowel Preparation Scale (BBPS).[8] The BBPS is a 9-point rating scale, rated from 0 to 3 depending on the degree of contamination of each of the 3 sections of the right colon, transverse colon, and left colon. A score of 0 indicates that solid stool is visible, a score of 1 indicates that mucosa is partially observed with residual stool and liquid, a score of 2 indicates that there is minimal residual but most of the mucosa is observable, and a score of 3 indicates that the entire mucosa is clear. The sum of the 3 parts indicates the degree of bowel preparation. A total score of 5 or less indicates poor bowel preparation, a score of 6 to 7 indicates good bowel preparation, and a score of 8 or more indicates very good bowel preparation.[8] Each item was scored by a doctor specializing in colonoscopy who performed the examination of each patient.

2.2.3. Bubble score
The bubble score used in this study is the scale reported by Sudduth et al,[9] and the total score was calculated as 0 to 15 points of the bubble index (0–3) for each of the 5 compartments (rectum, sigmoid colon, descending colon, transverse colon, and ascending colon). The bubble index is as follows. 0: No or minimal scattered bubbles, bubbles covering at least half the luminal diameter, bubbles covering the circumference of the lumen, bubbles filling the entire lumen.

2.3. Survey on compliance and satisfaction with taking bowel preparation solution

The questionnaire was distributed to all participants in the study while explaining and guiding the endoscopy, and a survey was conducted on the difficulties and satisfaction with taking bowel preparation solutions. The degree of difficulty in taking was divided into easy, common, and hard, and the reason for the difficulty in taking, whether the taste was good, not bad, or bad was investigated. In addition, side effects that occurred while
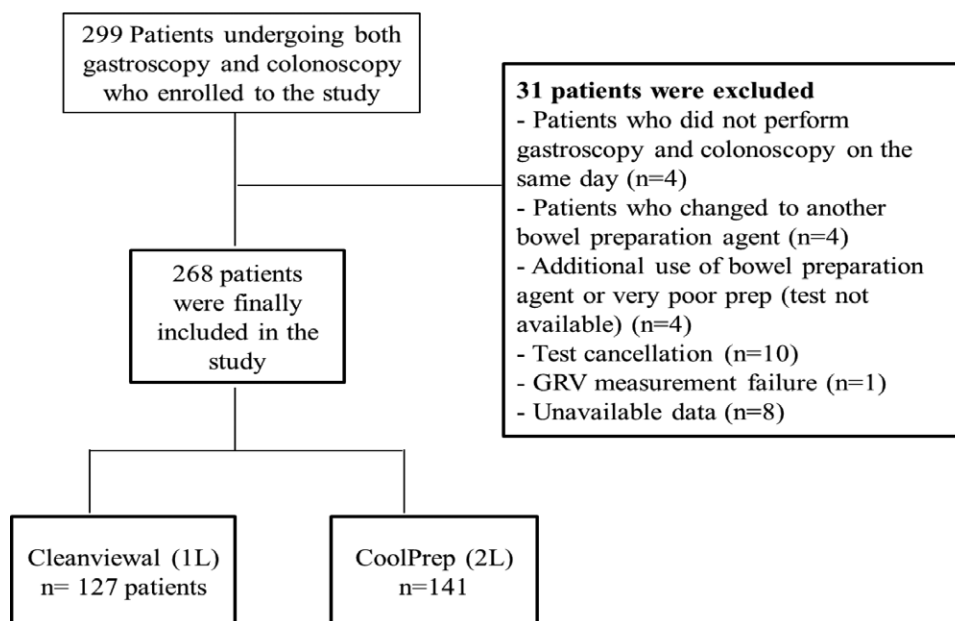

Figure 1. Patient enrollment.

taking the solution were written, and the will to take the bowel preparation solution again and satisfaction were investigated.

2.4. Polyp and adenoma detection

To find out the difference between polyp and adenoma according to bowel preparation solution, the number of polyps found in each compartment (cecum, ascending colon, transverse colon, descending/sigmoid colon, and rectum) was investigated during colonoscopy. In addition, adenoma was investigated by confirming the pathological results of the removed polyp.

2.5. Residual gastric volume

Since this study was aimed at patients undergoing gastro-colonoscopy at the same time, when first entering the stomach during the gastroscopy, the gastric volume existing in the stomach was separately suctioned to measure the volume through a secretion container. RGV was written in milliliter (mL), and when a nurse measured it, the doctor recorded the data in a separate format. The endoscopist was kept unaware of the preparation solution.

2.6. Statistical analysis

Variables were expressed as mean and standard deviation (SD) or as numbers and percentage. The baseline characteristics were compared using independent Student t- or Mann–Whitney tests for continuous variables and χ^2 or Fisher's exact tests for categorical variables, as appropriate. We compared the baseline characteristics, bowel preparation/bubble score, polyp/adenoma detection, and survey results between 1L PEG and 2L PEG group. RGV was divided into 20, 50, and 100 mL, and each independent predictor was analyzed using logistic regression analysis. The odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were calculated. In addition, the overall cumulative risk rates of RGV following volumes were determined using the Kaplan–Meier method and compared using log-rank tests. Data analysis was performed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY). P values < .05 were considered statistically significant. The graphs of the distributions of patients with GC and their pathologic findings were drawn using GraphPad Prism 6.0 (GraphPad Software, La Jolla, CA).

3. Results

3.1. Baseline characteristics

From May to October 2021, 268 patients underwent both gastro-colonoscopy and were enrolled in this study at 2 university hospitals in Busan, Korea. Bowel preparation was performed using 1L PEG in 127 patients and 2L PEG in 141 patients (Fig. 1). The baseline characteristics of subjects are shown in Table 1. In this study, 39.6% of the patients were male and mean age was 60 years. There were more of older (1L, 56.99 ± 9.30 vs 2L, 62.20 ± 9.05; P < .001) and diabetic patients (7.9% vs 17.1%; P = .023) assigned in the 2L PEG group when compared with the 1L PEG group (Table 1). Other factors were not significantly different between the 2 groups.

3.2. Bowel preparation related factors

3.2.1. Time to take bowel preparation and water intake The mean time from taking bowel preparation to gastroscopy was 5.91 hours (SD 2.63), and there was no significant difference between 5.98 ± 2.16 in 1L PEG and 5.8 ± 2.99 in 2L PEG (P = .681). Also, there was no significant difference between the 2 groups as the mean time of last water intake was 5.44 hours, but it was found that a larger amount of water was consumed at 2L PEG group than at 1L PEG group in the total water dose (1.81 ± 0.64 vs 2.57 ± 1.08; P < .001) (Table 2).

3.2.2. Bowel preparation and bubble score There was no significant difference between the 2 groups in BBPS to determine the degree of bowel preparation (all P > .05). However, in the bubble score, there were more bubbles overall in the 1L PEG group (1.91 ± 2.74 vs 1.10 ± 2.02; P = .007); they showed more bubbles in all areas except for the ascending colon when compared to the 2L PEG group (all P < .05) (Table 2).

3.3. Residual gastric volume

The mean value of the volume measured by aspiration of gastric juice when it first entered the stomach in a patient who underwent gastroscopy and colonoscopy at the same time was 37.16 mL (SD 49.98). 1L PEG showed significantly more RGV compared to 2L PEG (52.26 ± 65.33 vs 23.55 ± 22.99; P < .001) (Table 2). Even when RGV was divided into 20, 50,

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Table 1

Baseline characteristics of study subjects.

Variables	Total (n = 268)	Cleanviewal (1L) (n = 127, 47.4%)	CoolPrep (2L) (n = 141, 52.6%)	P value*
Male sex	106 (39.6)	49 (38.6)	57 (40.4)	.758
Age	59.73 ± 9.52	56.99 ± 9.30	62.20 ± 9.05	<.001
Weight	61.95 ± 10.95	63.03 ± 11.23	60.98 ± 10.64	.127
Height	162.35 ± 8.40	163.26 ± 8.74	161.54 ± 8.03	.095
BMI	23.41 ± 3.07	23.53 ± 3.00	23.30 ± 3.15	.535
Reason for colonoscopy				.986
Screening	191 (71.3)	91 (71.7)	100 (70.9)	
Surveillance	38 (14.2)	18 (14.2)	20 (14.2)	
GI symptom and others†	39 (14.6)	18 (14.2)	21 (14.9)	
Previous colonoscopy				
Yes	174 (85.7)	91 (86.7)	83 (84.7)	.688
None	29 (14.3)	14 (13.3)	15 (15.3)	
IBD patients	6 (2.2)	2 (1.6)	4 (2.8)	.486
Diabetes	34 (12.7)	10 (7.9)	24 (17.1)	.023

Data are expressed as mean ± standard deviation or n (%).
BMI = body mass index, IBD = inflammatory bowel disease.
†Tumor marker elevation, stool occult blood positive. *P value for comparing patients with cleanviewal solution and coolprep solution.

Table 2

Bowel preparation related factors of study subjects.

Variables	Total (n = 268)	Cleanviewal (1L) (n = 127, 47.4%)	CoolPrep (2L) (n = 141, 52.6%)	P value*
Time from taking bowel preparation to gastroscopy (h)	5.91 ± 2.63	5.98 ± 2.16	5.84 ± 2.99	.681
Time from last water intake to gastroscopy	5.44 ± 3.09	5.64 ± 3.42	5.25 ± 2.76	.305
Total water intake (L)	2.21 ± 0.98	1.81 ± 0.64	2.57 ± 1.08	<.001
Gastric residual volume (mL)	37.16 ± 49.98	52.26 ± 65.33	23.55 ± 22.99	<.001
≥20 mL	153 (57.1)	81 (63.8)	72 (51.1)	.036
≥50 mL	60 (22.4)	43 (33.9)	17 (12.1)	<.001
≥100 mL	26 (9.7)	24 (18.9)	2 (1.4)	<.001
Bowel preparation (BPPS)				
Total	8.42 ± 1.14	8.48 ± 1.08	8.36 ± 1.20	.396
Right colon	2.72 ± 0.51	2.76 ± 0.45	2.68 ± 0.55	.175
Transverse colon	2.82 ± 0.41	2.83 ± 0.39	2.82 ± 0.42	.705
Left colon	2.85 ± 0.41	2.86 ± 0.43	2.85 ± 0.40	.887
Bubble score				
Total	1.48 ± 2.42	1.91 ± 2.74	1.10 ± 2.02	.007
Ascending colon	0.51 ± 0.82	0.60 ± 0.88	0.43 ± 0.76	.103
Transverse colon	0.37 ± 0.69	0.46 ± 0.76	0.28 ± 0.61	.043
Descending colon	0.29 ± 0.62	0.40 ± 0.70	0.20 ± 0.51	.008
Sigmoid colon	0.18 ± 0.45	0.25 ± 0.53	0.11 ± 0.35	.010
Rectum	0.13 ± 0.44	0.20 ± 0.56	0.07 ± 0.26	.022

Data are expressed as mean ± standard deviation or n (%). Visual analogue scale score (0-10 points, 0: very bad, 10: excellent).

BPPS = The Boston bowel preparation scale.

*P value for comparing patients with cleanviewal solution and coolprep solution.

and 100 mL for comparison, it was confirmed that the residual volume was significantly higher in 1L PEG than in 2L PEG (all $P < .05$) (Table 2).

3.4. Polyp and adenoma detection

When the colon was divided into 5 segments (cecum, ascending colon, transverse colon, descending/sigmoid colon and rectum) and the number of polyps found was investigated, there was no significant difference between the 1L and 2L PEG groups. However, for adenoma detection, more adenomas were identified in the rectum in 1L PEG (6.3% vs 1.4%; $P = .036$). Also, when the examiner who performed the endoscopy evaluated the degree of satisfaction with the degree of bowel preparation subjectively considered, 88% were satisfied, and there was no significant difference between the 2 groups (Table 3).

3.5. Survey of compliance and satisfaction of taking the bowel preparation solution

There was no significant difference between 1L and 2L PEG in the question of whether it was difficult to take the bowel preparation, and about 70% of patients answered that it was easy or common to take (Table 4 and Fig. 2). When examining the reason for difficulty in patients who had difficulty taking the solutions, there was a significant difference in the amount of 2L PEG being too large (1L, 26.0% vs 2L, 41.8%; $P = .006$). However, 1L PEG had more associated symptoms compared to 2L PEG (1L, 34.6% vs 2L, 18.4%; $P = .003$), and the related symptoms answered as abdominal discomfort, bloating, nausea, and vomiting (Table 4 and Figs. 2 and 3). However, there was no significant difference between the 2 groups when examining the cases of side effects as an all subjects. As for whether or not to re-take the bowel preparation solutions, 59% of patients wanted to take it again, and 62%

Table 3

Polyp and adenoma detection of study subjects.

Variables	Total (n = 268)	Cleanviewal (1L) (n = 127, 47.4%)	CoolPrep (2L) (n = 141, 52.6%)	P value*
Polyp detection	143 (53.4)	67 (52.8)	76 (53.9)	.851
Cecum	18 (6.7)	8 (6.3)	10 (7.1)	.796
Ascending colon	70 (26.1)	36 (28.3)	34 (24.1)	.431
Transverse colon	51 (19.0)	23 (18.1)	28 (19.9)	.716
Descending & Sigmoid colon	73 (27.2)	35 (27.6)	38 (27.0)	.911
Rectum	24 (9.0)	14 (11.0)	10 (7.1)	.260
Adenoma detection	109 (40.7)	51 (40.2)	58 (41.1)	.871
Cecum	14 (5.2)	7 (5.6)	7 (5.0)	.829
Ascending colon	50 (18.7)	26 (20.5)	24 (17.1)	.486
Transverse colon	38 (14.2)	14 (11.0)	24 (17.0)	.160
Descending & Sigmoid colon	50 (18.7)	23 (18.1)	27 (19.1)	.827
Rectum	10 (3.7)	8 (6.3)	2 (1.4)	.036
Inspection Satisfaction by endoscopist				.489
Yes	236 (88.1)	110 (86.6)	126 (89.4)	
No	32 (11.9)	17 (13.4)	15 (10.6)	

Data are expressed as mean ± standard deviation or n (%).

*P value for comparing patients with cleanviewal solution and coolprep solution.

Table 4

A survey on the time and satisfaction of taking the bowel preparation solution.

Variables	Total (n = 268)	Cleanviewal (1L) (n = 127, 47.4%)	CoolPrep (2L) (n = 141, 52.6%)	P value*
Difficulty of taking				.698
Easy	118 (45.0)	54 (42.9)	64 (47.1)	
Common	77 (29.4)	37 (29.4)	40 (29.4)	
Hard	67 (25.6)	35 (27.8)	32 (23.5)	
Reason for difficulty of taking				
Taste	62 (23.1)	32 (25.2)	30 (21.3)	.447
Amount of solution	92 (34.3)	33 (26.0)	59 (41.8)	.006
Associated symptoms	70 (26.1)	44 (34.6)	26 (18.4)	.003
Taste				.057
Good	13 (4.9)	3 (2.4)	10 (7.2)	
Not bad	143 (54.2)	64 (50.8)	79 (57.2)	
Bad	108 (40.9)	59 (46.8)	49 (35.5)	
Side effect				.102
Yes	86 (32.1)	47 (37.0)	39 (27.7)	
Nausea and vomiting	63 (73.3)	36 (75.0)	27 (71.1)	.681
Abdominal discomfort, Bloating	25 (29.1)	14 (29.2)	11 (28.9)	.982
Dizziness	6 (7.0)	3 (6.3)	3 (7.9)	.766
Others†	9 (10.5)	6 (12.5)	3 (7.9)	.488
No	182 (67.9)	80 (63.0)	102 (72.3)	
Willingness to take again				.934
Yes	155 (59.6)	73 (59.3)	82 (59.9)	
No	105 (40.4)	50 (40.7)	55 (40.1)	
Overall satisfaction with bowel preparation solution				.969
Satisfy	44 (16.7)	20 (16.1)	24 (17.3)	
Common	164 (62.4)	78 (62.9)	86 (61.9)	
Dissatisfaction	55 (20.9)	26 (21.0)	29 (20.9)	

Data are expressed as mean ± standard deviation or n (%).
†Headache, epigastric pain, dry mouth, sour taste. *P value for comparing patients with cleanviewal solution and coolprep solution.
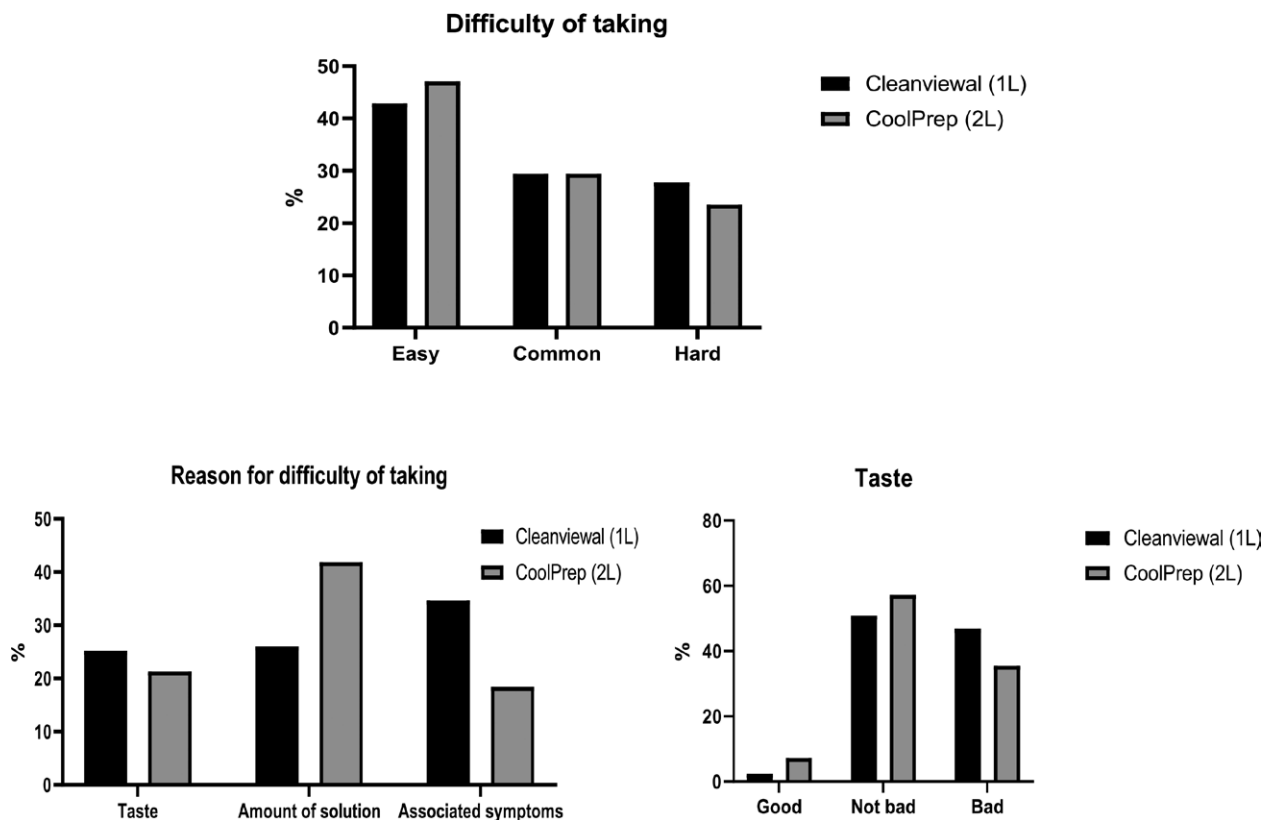

Figure 2. Comparison of difficulty of taking 1L and 2L PEG solutions. PEG = polyethylene glycol.
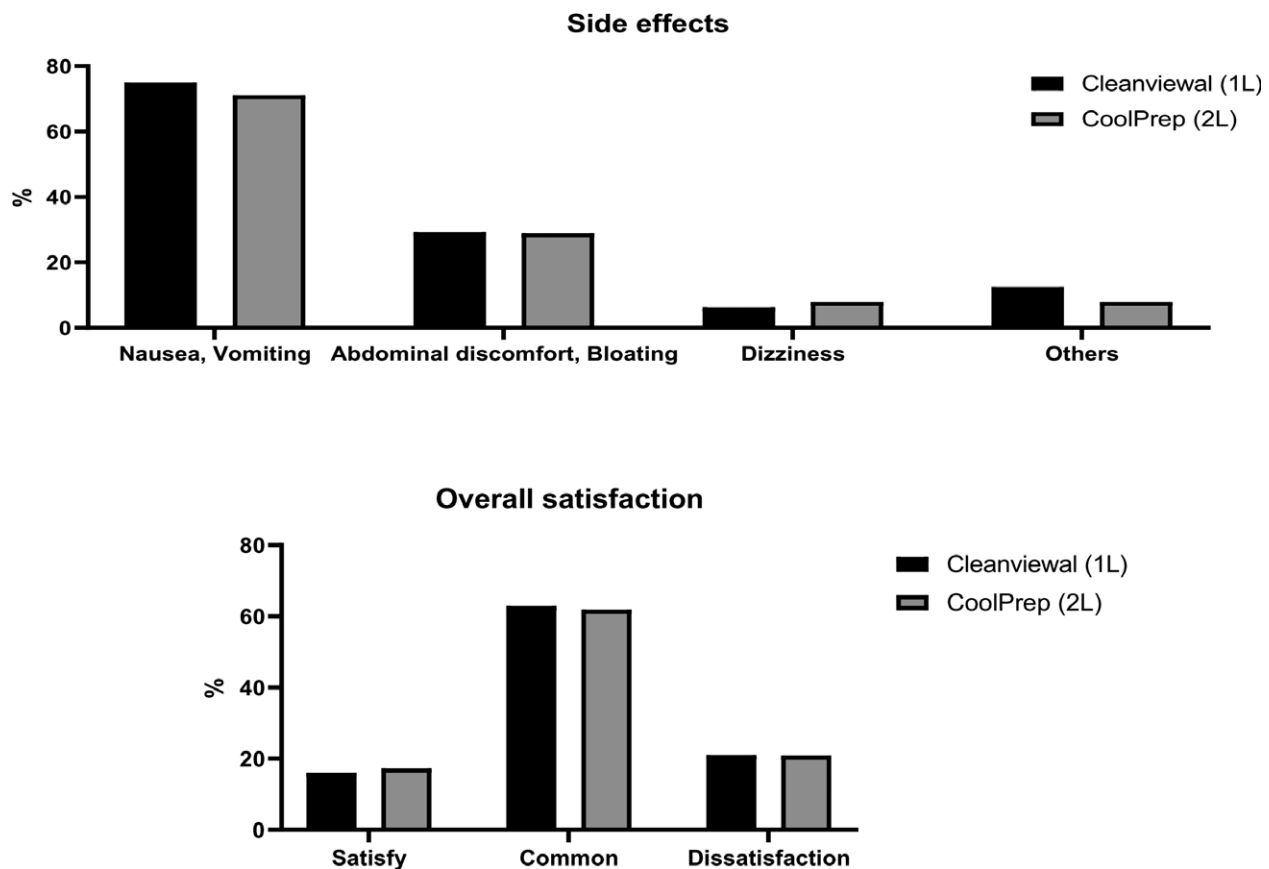
Figure 3. Comparison of side effects and overall satisfaction between 1L and 2L PEG solutions. PEG = polyethylene glycol.

of patients answered that they were average in overall satisfaction (Table 4 and Fig. 3).

3.6. Risk factors of RGV

The results of multivariate logistic regression analysis for each risk factor by dividing the RGV into 20, 50, and 100 mL are shown in Table 5. The results of logistic regression analysis of patients with RGV greater than 20 mL are described in Supplementary 1, http://links.lww.com/MD/H402 and Table 5. In patients with RGV ≥ 20 mL, the univariate logistic regression analysis showed that the shorter the time they last drank water before gastroscopy, the higher the risk of RGV (OR, 0.865; 95% CI, 0.785–0.953; P = .003). When analyzed by time, the risk of RGV ≥ 20 mL increased even within 6 hours (OR, 2.516; 95% CI, 1.480–4.277; P = .001). In addition, the survey showed a negative correlation in the case where the overall satisfaction was common (OR, 0.424; 95% CI, 0.204–0.880; P = .021), so it can be confirmed that there was not much RGV in the case where it is not difficult to take the bowel preparation solution in general (Table S1, http://links.lww.com/MD/H402). Among these variables, taking water within 6 hours (OR, 2.430; 95% CI, 1.410–4.187; P = .001) significantly increased risk of RGV ≥ 20 mL, and the case of common satisfaction (OR, 0.460; 95% CI, 0.216–0.979; P = .044) was a negative association of RGV ≥ 20 mL in the multivariate analysis (Table 5).

In the case of RGV ≥ 50 mL, the factors showing a significant difference in the multivariate analysis were water intake within 5 hours (OR, 2.086; 95% CI, 1.101–3.951; P = .024) and difficulty in taking the bowel preparation solution due to high amount of solution (OR, 2.234; 95% CI, 1.040–4.797; P = .039) (Table 5 and Table S2, http://links.lww.com/MD/H403). In the case of RGV ≥ 100 mL, the risk increased significantly in the

case of male (OR, 4.911; 95% CI, 1.531–15.752; P = .007), surveillance colonoscopy (OR, 3.526; 95% CI, 1.206–10.305; P = .021), water intake within 6 hours (OR, 5.257; 95% CI, 1.147–24.098; P = .033), and large amount of bowel preparation (OR, 3.701; 95% CI, 1.138–12.033; P = .030) in multivariate analysis. In addition, the younger the age, the more RGV left over 100 mL (OR, 0.948; 95% CI, 0.905–0.994; P = .027) (Table 5 and Table S3, http://links.lww.com/MD/H404). When comparing the cumulative risk of RGV between 1L and 2L PEG formulations with a log-rank curve, there was no significant difference in RGV ≥ 20 mL (P = .362). However, in RGV ≥ 50 and 100 mL, RGV showed a significant difference in 1L and 2L PEG according to the water intake time (P < .05) (Fig. 4).

4. Discussion

With the high prevalence of colorectal cancerp,[2,3] colonoscopy is already well known as an important modality that can prevent colorectal cancer and reduce mortality by detecting and removing colon adenomatous polyps.[10,11] Nevertheless, even with colonoscopy, interval cancer can occur.[12,13] It has been reported that the incidence of interval cancer is correlated with adenoma detection rate, which is an indicator of the quality of colonoscopy.[13] There are several indicators in determining the quality of colonoscopy.[1,14] Among them, the most basic prerequisite to be satisfied is the proper bowel preparation for complete colonoscopy.[1,15] For proper bowel preparation, many types of bowel preparation have been developed and used. From large volume PEG to low volume PEG and oral tablet, many efforts have been made to increase patient compliance. Accordingly, in PEG drugs that are safely used as iso-osmotic without electrolyte imbalance,[16] 1L PEG, which is a smaller dose, has recently been developed and used. In this study, 1L PEG was not inferior

Table 5

Comparison of risk factors according to residual gastric volume.

Variable	≥20 mL		≥50 mL		≥100 mL	
	P value	Adjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value	Adjusted OR (95% CI)
Male sex	.902	0.967 (0.569-1.646)	0.968	1.014 (0.524-1.962)	.007	4.911 (1.531-15.752)
Age	.078	0.976 (0.949-1.003)	0.121	0.975 (0.945-1.007)	.027	0.948 (0.905-0.994)
Reason for colonoscopy						
Screening			0.100	1.0 (Ref.)	.045	1.0 (Ref.)
Surveillance			0.133	1.857 (0.829-4.163)	.021	3.526 (1.206-10.305)
GI symptom and others†			0.198	0.499 (0.173-1.436)	.664	0.738 (0.187-2.909)
Time from last water intake to gastroscopy						
<4 h						
<5 h			0.024	2.086 (1.101-3.951)		
<6 h	.001	2.430 (1.410-4.187)			.033	5.257 (1.147-24.098)
<7 h						
Reason for difficulty of taking						
Taste						
Amount of solution			0.039	2.234 (1.040-4.797)	.030	3.701 (1.138-12.033)
Associated symptoms						
Overall satisfaction with bowel preparation solution						
Satisfy	.122	1.0 (Ref.)	0.415	1.0 (Ref.)		
Common	.044	0.460 (0.216-0.979)	0.314	0.662 (0.297-1.478)		
Dissatisfaction	.255	0.598 (0.247-1.450)	0.956	1.028 (0.387-2.731)		
Total BPPS			0.318	1.223 (0.824-1.818)		
Right colon BPPS					.081	6.351 (0.794-50.801)
Inspection Satisfaction by endoscopist			0.207	0.358 (0.073-1.763)		

BMI = body mass index, CI = confidence interval, GI = gastrointestinal, OR = odds ratio.
†Tumor marker elevation,
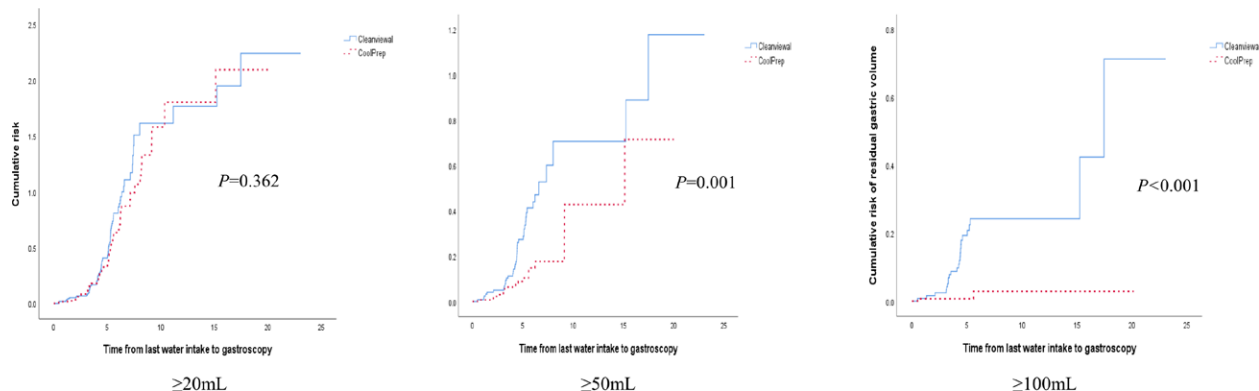stool occult blood positive.

Figure 4. Cumulative risk of residual gastric volume between 1L and 2L PEG preparation (Kaplan-Meir graph). PEG = polyethylene glycol.

in bowel preparation compared to 2L PEG, but showed that the bubble score was higher overall. In addition, the RGV of 1L and 2L PEG was compared to reveal relevant factors and showed that the time of water intake is important.

Concerns about RGV in colonoscopy, which mainly progress to deep sedation, have been around for a long time,[17-19] and more research on low-dose PEG is needed. Huffman et al reported that RGV was significantly higher in patients who underwent split-dose bowel preparation compared with gastroscopy alone.[19] Cheng et al also showed that the mean RGV of patients receiving same-day bowel preparation (35.4 mL) was significantly higher than the mean RGV of patients receiving split-dose bowel preparation (28.5 mL).[5] In another study, in 150 patients undergoing gastroscopy and colonoscopy, 75 patients who received split-dose preparation up to 2 to 3 hours before endoscopy compared the RGV of those who completed the preparation the day before, but there was no significant difference in RGV (21 ± 24 mL vs 24 ± 22 mL).[17] In other words, it can be seen that the risk of RGV is lower with split-dose bowel preparation than with EGD alone or same-day bowel

preparation. However, as different results may appear depending on the type of bowel prep drug or the time of bowel prep, there are still controversial points in each study. In our study, we were able to compare the RGV of 1L PEG and 2L PEG itself because all patients undergoing gastroscopy and colonoscopy were prepared with split-dose preparation.

Previous studies investigating RGV mainly reported RGV of about 20 to 25 mL.[5,17-19] However, during enteral nutrition in critically ill patients, RGV at risk of aspiration is reported from 50 to 500 mL.[20-23] Therefore, in this study, analysis was carried out by dividing the volume up to 20, 50, and 100 mL. When the risk factors were analyzed by the amount of RGV, the risk factor was when the last water intake was within 6 hours for 20 mL, but water intake within 5 hours for 50 mL and more than 100 mL for men, young patients, and water intake within 6 hours was an important risk factor (Table 5). In other words, it is highly likely that the bowel preparation was not performed completely in the case of a young man undergoing screening or surveillance colonoscopy. Also, in many studies, following the American Society of Anesthesiologists guideline,[7] analysis was

based on 2 to 3 hours interval for sedation after completing bowel preparation,[5,17,19] but most of the subjects in this study completed taking the bowel preparation 5 to 6 hours before the colonoscopy, so there is no significant difference in fasting time after bowel preparation.

Several studies have reported that 1L PEG is not inferior to 2L PEG or other bowel preparations.[24-26] Xin Y et al reported that there were no significant differences in appropriate bowel preparation rates and complication rates in a meta-analysis of randomized, controlled trials with 1L PEG and 2L PEG.[27] Instead of improving compliance and taste, 1L PEG has raised concerns regarding the risk of hypernatremia and dehydration in patients with renal dysfunction and electrolyte shifts that can lead to serious clinical consequences.[28] However, several studies have not yet reported serious abnormalities in electrolyte balance.[25,26] Also in our study, there was no significant difference between 1L and 2L PEG in side effect. However, as the drug dose was reduced, the subjectively felt related symptoms of the patients were higher with 1L PEG. However, this was reported by 70 out of 268 patients (26.1%), and 67.9% of patients did not complain of any side effects. This shows that the subjective thoughts may have been involved with the survey. In addition, 1L PEG (Cleanviewal®) contains ascorbic acid with PEG 3350 from 9.4g to 40.6g compared to 2L PEG, and the capacity of ascorbic acid is very high. Vitamin C is a necessary element for our body, but if taken in excess, side effects such as diarrhea, abdominal pain, acid indigestion, and frequent urination may occur.[29,30] Also an increase in gastric juice secretion may lead to a decrease in pH,[31] which may cause an increase in RGV. Therefore, the causes of the increase in RGV of 1L PEG may be various, but what we know from this study is that it is desirable to reduce water intake within 5 hours before the colonoscopy.

Through our study, appropriate bowel preparation can be achieved even with 1L PEG, but bubbles may remain, so it is necessary to check whether additional simethicone may be needed, and the time of water intake is important for RGV. However, this study had several limitations. First, electrolyte and pH were not investigated in this study. However, it is an advantage that the factors related to bowel preparation were investigated and analyzed in detail for patients. Second, as the survey was conducted together, bias could occur depending on the patient's information. For example, when examining the amount of water intake, it is possible to calculate the amount of water mixed with bowel preparation powder according to the patient's thoughts, which may cause a bias. Lastly, the fact that most of the patients were healthy patients who underwent colonoscopy as screening or surveillance may indicate a selective bias. Also, even though the bowel preparation solution was randomly assigned, 1L PEG was often assigned to younger patients, so the proportion of diabetic patients was different from the beginning. However, this study investigated the RGV of 1L PEG in many patients and showed the importance of the time taken for water in 1L PEG.

5. Conclusion

RGV was significantly increased in 1L PEG compared to 2L PEG, which increases the risk if the last water dose was within 5 hours. Therefore, since RGV is higher in 1L PEG than in 2L PEG, it is necessary to be careful not to take water for at least 5 hours before the test.

Author contributions

Guarantor of the article: Tae Oh Kim.
Specific author contributions: Yong Eun Park: data acquisition; data analysis and interpretation; manuscript drafting. Su Jin Jeong: data acquisition; study concept and design. Jin Lee: data acquisition; study concept and design. Jongha Park: study concept and design; critical revision of the manuscript for important intellectual content. Seung Jung Yu: study concept and design; critical revision of the manuscript for important intellectual content. Sam Ryong Jee: study concept and design; critical revision of the manuscript for important intellectual content. Tae Oh Kim: data acquisition; study concept and design; critical revision of the manuscript for important intellectual content. All authors approved the final version of the article, including the authorship list.
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