

# A Korean experience of the use of Boston Bowel Preparation Scale: A Valid and Reliable Instrument for Colonoscopy-Oriented Research

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## ABSTRACT

**Background/Aims:** Few bowel preparation scales have been validated. The Boston Bowel Preparation Scale (BBPS) is a novel bowel preparation scale in western countries. We validated the BBPS in Korean patients and assessed the relationship between the colon polyp detection rate and BBPS score. **Patients and Methods:** This study was a prospective, single-center trial. The BBPS is a 10-point scale that assesses bowel preparation after the completion of all cleansing maneuvers. We assessed three segment scores (the right side, transverse section, and left side) and total BBPS scores during screening colonoscopy. In addition, we compared the BBPS scores with clinically meaningful outcomes such as the polyp detection rate and colonoscopy withdrawal times. **Results:** We enrolled 482 screening colonoscopies between January 2011 and January 2012. The mean ( $\pm$  standard deviation [SD]) BBPS score was  $8.1 \pm 1.1$ . Higher BBPS scores ( $\geq 8$  vs  $< 8$ ) were associated with a higher polyp detection rate (44.9% vs. 33.0%,  $P = 0.042$ ). The BBPS scores were inversely correlated with colonoscopy withdrawal times ( $r = -0.167$ ,  $P < 0.001$ ). **Conclusions:** The BBPS is a valid and reliable measure for assessing bowel preparation during colonoscopy in Korean patients. The polyp detection rate is higher in patients with higher BBPS scores than in those with lower BBPS scores during a colonoscopic procedure.

**Key Words:** Boston bowel preparation scale, bowel preparation, colonoscopy, polyp detection rate

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Colorectal cancer is the second leading cause of cancer-related death in the United States.<sup>[1]</sup> The incidence of colon cancer in Asian countries, including Japan, China, and Korea, is increasing.<sup>[2]</sup> Numerous reports indicate that polyp removal reduces the incidence of colorectal cancer; therefore, various guidelines regarding the timing of initial colorectal cancer screening colonoscopies and follow-up intervals have been published.<sup>[3,4]</sup>

To reduce the occurrence of colorectal cancer by using

colonoscopy screenings, the colonic mucosa must be well visualized. Many factors can affect adequate observation of the colon mucosa, including clinical patient characteristics, observer skill, and bowel preparation.

Among these factors, poor bowel preparation can cause missed polyps, prolong the procedure duration, and increase unnecessary costs due to repeated procedures. In particular, a missed polyp can have a negative impact on colon cancer prevention through colonoscopy examination.<sup>[5]</sup>

Despite the clinical importance of bowel preparation, reliable bowel preparation rating scales are not yet commonly used. The American Society for Gastrointestinal Endoscopy (ASGE) and American Gastroenterological Association (AGA) Task Force proposed the use of terms such as “excellent,” “good,” “fair,” and “poor,” but admitted that these terms lack standardized definitions.<sup>[6]</sup> In the past, several bowel preparation rating scales were developed; however, they were designed to compare

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the efficacy of two or more bowel preparation methods and were flawed by the absence of a reliability scale.

Among several reliable bowel preparation rating scales, the Boston Bowel Preparation Scale (BBPS) was introduced recently as a measure that received good intra- and interobserver reliability assessments [Table 1].<sup>[7]</sup> However, the scale might be limited in its generalizability. Especially, only a few studies are published about this scale in Asian countries. Therefore, we performed a prospective study to assess the effectiveness of the BBPS in Korean patients.

## PATIENTS AND METHODS

### Subjects

This study was a prospective, single-center trial. Between January 2011 and January 2012, participants who visited the outpatient clinic or health examination center at Seoul Paik Hospital for colon cancer screening colonoscopy were recruited. Patients who had received a colonoscopy within the last 10 years or had a past history of colon cancer, colon adenoma, inflammatory bowel disease, prior colonic resection, or incomplete colonoscopy for reasons other than poor bowel preparation were excluded. A total of 482 patients who had no exclusion criteria were enrolled.

The endoscopist noted the bowel preparation; cecal insertion and withdrawal times; and the presence or absence, number, size, and location of any polyp. If a colon polyp was found, we performed a polypectomy with biopsy forceps or snare during withdrawal phase of colonoscopy. We also observed histological type of colon polyp, grade of dysplasia, and gross findings. This study was approved by the Seoul Paik Hospital Institutional Review Board.

### Bowel preparation methods

For the morning colonoscopy, the patients were instructed to consume 2 L of polyethylene glycol (PEG, Colyte-F®, Tae-Joon Pharmaceutical Company, Seoul, Korea) between

8:00 pm and 10:00 pm on the evening before the colonoscopy and then to consume the remaining 2 L of PEG from 5:00 am to 7:00 am on the day of the procedure. Patients scheduled for afternoon colonoscopy were instructed to consume 4 L of PEG from 7:00 am to 11:00 am on the day of the procedure. A total of 205 patients (42.5%) underwent colonoscopy in the morning, whereas 277 patients had the procedure in the afternoon (57.5%).

### Assessment of bowel preparation

The colonoscopies were performed by six endoscopists with more than 10 years of experience in performing colonoscopies, during which each had performed more than 1000 colonoscopies. An Olympus colono-videoscope (Eivs Lucera Gastrointestinal Videoscope OLYMPUS CF-Q260AL, CF-H260AL, Olympus Optical Co., Ltd, Japan) was used in all colonoscopies in this study. Sedation was achieved with 0.5 mg/kg of midazolam and 25 mg of meperidine intravenously. The sedation level was monitored to ensure that the level was maintained between 2 and 3 in the Modified Observer's Assessment of Alertness/Sedation (OAA/S) Scale, which indicates that a patient responds only to mild shaking or responds only after name is called loudly.<sup>[8]</sup> We downloaded a free 15-min instructional training video supplied by the BBPS developers on their website and practiced giving the assessment until a substantial degree of agreement was achieved. The BBPS divides the colon into three broad regions: The right side of the colon (including the cecum and ascending colon), the transverse section of the colon (including the hepatic flexure, transverse colon, and splenic flexure), and the left side of the colon (including the descending colon, sigmoid colon, and rectum). Points were assigned as shown in Table 1 and Figure 1. We measured the BBPS score and the ASGE bowel preparation rating scale during the colonoscopic examination for each patient and saved these data in the form of DVDs and photographs. The ASGE bowel preparation rating scale assesses the preparation quality of the entire colon as follows: 1, excellent (no or minimal solid stool); 2, good (no or minimal solid stool with large amounts of clear fluid requiring suctioning); 3, fair (collections of semisolid debris that are cleared with difficulty); 4, poor (solid or semisolid debris that cannot be effectively cleared). We also investigated the correlation between these two assessment tools. Then, we selected randomized patients and estimated the BBPS scores by observing the DVDs and photographs. We obtained inter- and intrarater reliability ratings by comparing two data points.

### Statistical analysis

We calculated the mean total BBPS score for each possible categorical assessment ("excellent," "good," "fair," and "poor") and obtained a *P* value for the mean trend using linear regression. We determined the polyp or adenomatous

**Table 1: The boston bowel preparation scale<sup>a</sup>**

Segment score	Description
0	Unprepared colon segment with mucosa not seen due to solid stool that cannot be cleared
1	Portion of mucosa of the colon segment seen, but other areas of the colon segment are not well seen due to staining, residual stool, and/or opaque liquid
2	Minor amount of residual staining, small fragments of stool, and/or opaque liquid, but mucosa of colon segment is seen well
3	Entire mucosa of colon segment seen well, with no residual staining, small fragments of stool or opaque liquid

<sup>a</sup>Total score is a summation of scores from three segments of the colon

polyp detection rate for each BBPS score, dichotomized score ( $<8$  or  $\geq 8$ ), and assessed their correlations using Chi-square tests. Colonoscopy insertion and withdrawal times were correlated with BBPS scores by using the Pearson's correlation coefficient. All calculations were performed by using the Statistical Package for the Social Sciences (SPSS) software version 18.0 (SPSS Inc, Chicago, IL, USA), and  $P < 0.05$  were considered significant.

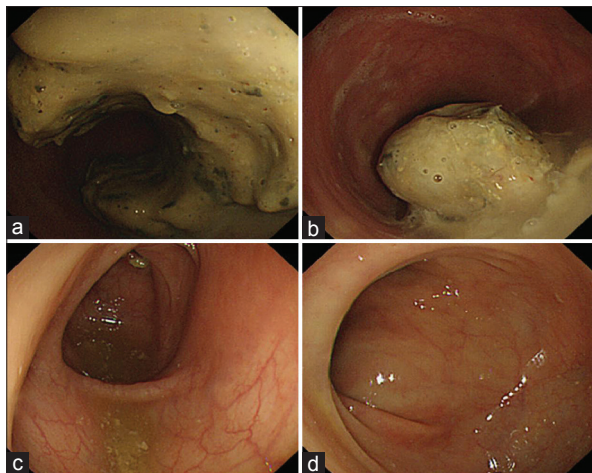
## RESULTS

### Patient characteristics

A total of 482 patients who underwent colorectal cancer screening were enrolled in the study. The patient characteristics of gender, age, height, weight, body mass index (BMI), history of abdominal surgery, conscious sedation endoscopy, and cecal intubation rate are shown in Table 2. The mean ( $\pm$ SD) age was  $47.3 \pm 9.4$  years, and the average ( $\pm$ SD) BMI was  $23.9 \pm 3.7$  kg/m<sup>2</sup>. Patients with a history of abdominal surgery numbered 74 (15.4%); among these patients, 36 had undergone hysterectomy or gynecologic surgery (48.6%).

### BBPS score

When the BBPS was used prospectively during the 482 screening colonoscopies, the mean ( $\pm$ SD) BBPS score was  $8.1 \pm 1.1$ . Ninety-seven (20.1%) colonoscopies were given a BBPS score  $<8$ , whereas the remainder had a BBPS score  $\geq 8$  ( $n = 385$ , 79.9%). The frequency of actual BBPS scores was based on "real" colonoscopic evaluations and the



**Figure 1:** The boston bowel preparation scale. (a) segment score 0: unprepared colon segment with mucosa not seen due to solid that cannot be cleared. (b) segment score 1: Portion of mucosa of the colon segment seen, but other areas of the colon segment not well seen due to staining, residual stool, and/or opaque liquid. (c) segment score 2: Minor amount of residual staining, small fragments of stool and/or opaque liquid, but mucosa of colon segment seen well. (d) segment score 3: Entire mucosa of colon segment seen well with no residual staining, small fragments of stool, and/or opaque liquid

frequency of indirect BBPS scores was based on data from DVDs and photographs. The distribution approximated a crescendo-shaped curve [Figure 2].

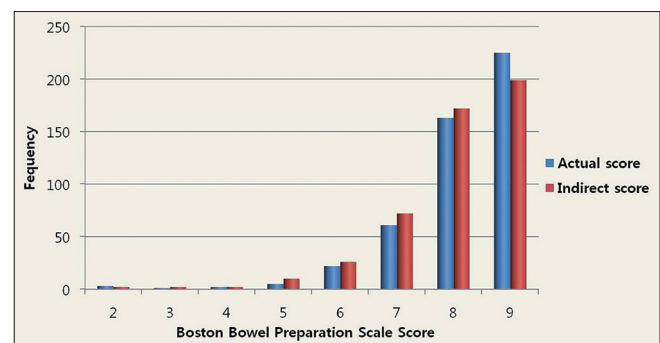
The BBPS demonstrated strong interobserver reliability, with an intraclass correlation coefficient (ICC) of 0.90 over the full range of possible total BBPS scores. The interobserver reliability was obtained by a weighted kappa value of 0.63 (95% confidence interval [CI], 0.57-0.68) over the full range of possible total BBPS scores. The inter- and intraobserver reliability for BBPS segment scores according to location was also similar in the right and transverse colon. However, there was a relatively lower ICC and weighted kappa value for the left colon [Table 3].

There was no significant difference in mean BBPS scores according to patient characteristics, including age, gender, BMI, or past history of abdominal surgery ( $R^2 = 0.001$ , 0.002, 0.000, and 0.000,  $P = 0.56$ , 0.29, 0.77, and 0.82, respectively). Moreover, according to the procedure time, there was no difference in mean BBPS scores (morning,  $8.04 \pm 1.13$  vs. afternoon,  $8.10 \pm 1.20$ ,  $P = 0.110$ ).

### Colon polyp, adenoma, advanced adenoma, and cancer detection rate

Among the 482 patients who underwent a colonoscopy, 203 had a polyp (42.1%), 136 had an adenoma (28.4%), 23 had an advanced adenoma (4.8%), and 1 had cancer (0.2%).

The polyp detection rate was 44.9% for patients with a BBPS score  $\geq 8$ , compared with 33.0% for patients with a BBPS score  $<8$ . The likelihood of detecting polyps was increased in patients with higher BBPS scores compared with those with lower BBPS during the colonoscopic procedure ( $P = 0.042$ , Table 4). In addition, we compared the quantitative rates of polyp detection in each segment by calculating the segment



**Figure 2:** Distribution of boston bowel preparation scale scores applied during 482 actual and indirect method. BBPS score of actual evaluation was performed during colonoscopy, based on the real vision. BBPS score of indirect evaluation was performed after colonoscopy, based on the vision of DVD and photograph. The distribution approximates a crescendo-shaped curve

scores. Individual BBPS segment scores in the right side of the colon showed a positive trend with the polyp detection rate ( $r = 0.107$ ,  $P = 0.018$ ). However, the individual BBPS segment scores in the left side and transverse section of the colon were not associated with significant polyp detection rates [Table 5].

The total BBPS score was inversely correlated with the colonoscopy withdrawal time ( $r = -0.175$ ,  $P < 0.001$ ), but not insertion time ( $r = 0.018$ ,  $P = 0.695$ ).

### Correlation between BBPS score and ASGE bowel preparation rating

When considering the ASGE bowel preparation ratings used during the colonoscopies (excellent, good, fair, and poor), we noted a significant decreasing trend in the BBPS

score assigned for each category ( $r = -0.646$ ,  $P < 0.001$ ). This finding indicates that the higher BBPS scores were significantly associated with a better ASGE assessment.

### Correlation between BBPS score and polyp size

The polyp size was  $<5$  mm in 108 (53%) participants, 5-9 mm in 74 (36%), 10-14 mm in 8 (3.9%), 15-19 mm in 3 (1.4%) and  $\geq 20$  mm in 10 (4.9%), with the most frequent polyp size being  $<5$  mm.

Adenomas were the most frequent histological polyp classification ( $n = 136$ , 67.0%), followed by hyperplastic polyps ( $n = 41$ , 20.2%), inflammation ( $n = 19$ , 9.4%), and serrated polyp ( $n = 7$ , 3.4%). Tubular adenomas were the most frequent histological type of colon adenoma ( $n = 126$ , 92.6%), followed by 9 (6.6%) villotubular adenomas, and 1 (0.7%) invasive carcinoma. Among the patients with adenomas, low-grade dysplasia was observed in 123 (89.8%) participants, and 7 (5.1%) had high-grade dysplasia. There was no statistically significant difference between the total BBPS score and polyp size ( $r = 0.136$ ,  $P = 0.053$ ).

## DISCUSSION AND CONCLUSIONS

Bowel preparation has been addressed in many colonoscopy studies, two or more of which have compared the effectiveness of bowel preparation.<sup>[9-14]</sup> At a minimum, bowel preparation scales should be valid and reliable. Without reliability, even a valid scale can result in differences between study groups attributed to the application of the scale, as opposed to the interventions themselves.<sup>[15]</sup>

In addition to bowel preparation assessments used by the ASGE and AGA Task Force, other bowel preparation rating scales were developed, but were limited by lack of a reliable evaluation. For example, the Aronchick scale provides descriptions of the percentage of fluid and stool coverage and uses a scale of "excellent," "good," "fair," "poor," and "inadequate;" however, the interobserver reliability was inferior and the intraobserver reliability was not reported.<sup>[15-17]</sup> The Ottawa scale uses a rating for three segments, the cecum-ascending colon, transverse-descending colon, and rectosigmoid colon, and assesses segment cleanliness with a score of 0-4 and fluid volume for the entire colon with a score of 0-2.<sup>[15,18]</sup> This scale was validated only by comparison to the Aronchick scale; no data were reported regarding its

Patients (number)	482
Male (%)	335 (69.5%)
Age (years)	47.3±9.4
Height (cm)	167±8.3
Weight (kg)	67.9±11.8
BMI	23.9±3.7
History of abdominal surgery (%)	74 (15.4%)
Large bowel	24 (32.4%)
Small bowel	1 (1.4%)
Stomach	8 (10.8%)
Gallbladder	4 (5.4%)
C/sec or hysterectomy	36 (48.6%)
Liver	1 (1.4%)
Sedation (%)	474 (98.3%)

BMI: Body mass index, C/sec: Cesarean section. The values are expressed as % or mean±SD

	Total score	Rt-colon score	T-colon score	Lt-colon score
ICC	0.90	0.93	0.88	0.50
Weighted kappa (95% CI)	(0.57-0.68)	(0.88-0.94)	(0.80-0.92)	(0.28-0.46)

ICC: Intraclass correlation coefficients, BBPS: Boston bowel preparation scale, Rt-colon: Right side colon, T-colon: Transverse section, Lt-colon: Left side colon, CI: Confidence interval

	Polyp		Adenoma		Advanced adenoma	
	N (%)	P value	N (%)	P value	N (%)	P value
BBPS $<8$	32/97 (33.0)	0.042	26/97 (26.8)	0.719	1/97 (1.0)	0.053
BBPS $\geq 8$	171/385 (44.4)		110/385 (28.6)		22/385 (5.7)	

BBPS: Boston bowel preparation scale, N: Number. Statistical analysis was evaluated by Chi-square test

**Table 5: BBPS segment score and colon polyp detection rate**

BBPS score	Rt-colon polyp	
Rt-colon	Spearman's r	0.107
	P value	0.018
	T-colon polyp	
T-colon	Spearman's r	-0.196
	P value	0.156
	Lt-colon polyp	
Lt-colon	Spearman's r	0.059
	P value	0.198

BBPS: Boston bowel preparation scale, Rt-colon: Right side colon, T-colon: Transverse section, Lt-colon: Left side colon. Statistical analysis was evaluated by bivariate correlation

correlation with other colonoscopy outcomes. Interobserver reliability was tested, but intraobserver reliability was not assessed.<sup>[11,16]</sup> In our study, we have established intra- and interobserver reliability by comparisons of actual and indirect measurement of BBPS scores, which were verified statistically using ICCs and weighted kappa values.

On the other hand, the BBPS is used to evaluate inter- and intraobserver reliability by use of an instructional DVD, to calculate scores during the withdrawal phase of a colonoscopy after all cleaning maneuvers, and to evaluate the degree of bowel segment cleanliness. A post-cleaning maneuver (washing with clean water and suction of fecal material) scale reflects a more realistic view of the colonoscopic procedure. In the “real-life” setting, the endoscopist performs the cleaning maneuver for better visualization and then begins to detect abnormal lesions. The BBPS can also be used as a total score (e.g., 5), individual segment scores (e.g., 3-2-0), or both (e.g., 3-2-0 = 5) to fit the user's needs. This segment assessment may help to preserve segmental differences in bowel preparation quality. Thus, it is possible to conduct a more precise evaluation of the entire and segmental colon. As such, the BBPS may be useful for screening colonoscopies, clinical trials, or research.<sup>[7]</sup>

Similar to conventional BBPS research, in this study, the BBPS training and testing DVD was viewed by six members of our gastroenterology division, who have more than 10 years experience in performing colonoscopies. These individuals viewed the DVD twice, and then the degree of agreement was considered substantial. Our study also found that a significantly higher total BBPS score was associated with a higher polyp detection rate and a shorter colonoscope withdrawal time, suggesting that better bowel preparation may lead to shorter cleanliness maneuvers and procedure time. However, there were no significant relationships between the BBPS score and patient gender, age, BMI, or past history of surgery. These results were inconsistent with another study that revealed that older age (odds ratio 1.07) was independently

associated with poor bowel preparation.<sup>[19]</sup> We also expected that older age would be correlated with a lower a BBPS score; however, participants older than 65 years accounted for only approximately 3% of our study population, thus no relationship between the BBPS score and age was observed. In this study, there was a significant correlation between the BBPS score and polyp detection rate. However, there was no significant difference between the BBPS score and polyp size ( $r = 0.134$ ,  $P = 0.056$ ). The high BBPS scores (8.1 points) of this study compared with other studies<sup>[20-22]</sup> and the frequent small polyps (<5 mm) might have affected our results. The relationship between the right side segment scores and a positive trend with polyp detection rates is consistent with another study conducted by the BBPS developer.<sup>[16]</sup> There was a correlation between the ASGE grade and BBPS, suggesting that better bowel preparation as evaluated by the BBPS was associated with better bowel preparation according to the conventional ASGE ratings. It is well known that poor bowel preparation can cause missed polyps, prolong the duration of the procedure, and increase unnecessary costs associated with repeated procedures. Therefore, the introduction and use of the bowel preparation scale, which has good intraobserver reliability, can improve the consensus among endoscopists. We suggest that through the consensus achieved with the use of the BBPS scale, unnecessary costs associated with repeated procedures may be reduced. In these regard, using the BBPS scale would be cost-effective.

To date, only one study has reported BBPS score use in bowel preparation assessment research in Korea.<sup>[19]</sup> However, the purpose of the study was to assess the effect of patient education by using cartoon visual aids on the quality of bowel preparation, not the validation of BBPS in a Korean population. The present study is noteworthy in that patients with high BBPS scores have an advantage in colon polyp detection rates compared with those with low BBPS scores. Recently, a large body of research using the BBPS was published in the West. Samarasena *et al.*<sup>[20]</sup> evaluated the efficacy of bowel cleansing according to preparation group (split/whole-dose Golytely vs. Miralax) by using the BBPS score. They reported that the mean BBPS score ranged from 6.07 to 8.33 among the groups. Other Western studies<sup>[21,22]</sup> also reported a mean BBPS score of 6 or 7 and polyp detection rate of 21%-38%; these values were lower than those of our present study. The differences in results can be explained by the following reasons. First, the degree of Korean patients' bowel cleanliness may be high in comparison to Western patients, as reported by Calderwood *et al.*<sup>[16]</sup> Second, we performed more rigorous bowel preparation education than other studies. Third, our exclusion criteria were more extensive than those of other studies.

The present study has several limitations. First, it took place at a single center, thus potentially limiting the generalizability

of our results. Second, the high mean BBPS score (8.1 points) skewed the BBPS distribution. As such, the results for adenoma size, insertion time, and segment polyp detection rate of the transverse and left side of the colon according to the BBPS score did not meet our expectations. Third, we did not evaluate patient compliance and abdominal discomfort during the colonoscopic examination. Nevertheless, the BBPS scale showed good intraobserver reliability and correlated well with the ASGE scale. Moreover, the BBPS scale reflects a realistic view of the colonoscopic procedure. Therefore, using a valid and reliable scale for bowel preparation would be cost-effective because it could result in good consensus among endoscopists.

In conclusion, the BBPS is a valid and reliable instrument for assessing bowel preparation adequacy during screening colonoscopies in Korea. We also assume that this score is useful in other Asian countries. There was a significant correlation between the BBPS score and colon polyp detection rates. Additionally, there was a significant correlation between the BBPS score and colonoscope withdrawal time.

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