Correlation of Cleanliness among Different Bowel Segments during Colonoscopy: A Retrospective Study

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Objective. To analyze the correlation of intestinal cleanliness in each segment of the Boston Intestinal Preparation Scale.

Methods. From February 2017 to October 2019, the data of patients who underwent colonoscopy in the Department of Gastroenterology, Hangzhou First People’s Hospital, Zhejiang University School of Medicine, were collected. Statistical analysis was performed according to the Boston Intestinal Preparation Scale score, and the correlation of intestinal cleanliness in each region was obtained. Results. A total of 1739 patients were included. The overall score of BBPS was 6.77 ± 1.88. The scores of each region were 2.04 ± 0.84 (right lateral colon), 2.25 ± 0.68 (transverse colon), and 2.48 ± 0.64 (left colon). The difference between the regions was statistically significant ($P < 0.05$). The bowel cleanliness showed a gradual deterioration trend, and there was a positive correlation between colon cleanliness in each region. The accuracy of the transverse colon in predicting the right colon cleanliness ($AUC = 0.809$) is higher than that of the left colon ($AUC = 0.735$), and the accuracy of predicting the cleanliness of the right colon intestinal tract by the cleanliness of the left colon intestinal tract is relatively low. Conclusion. Intestinal cleanliness gradually deteriorates from the direction of the insert. It is not reliable to predict the right side of poor cleanliness by using the left colon intestinal cleanliness (BBPS 0-1 score). It should continue to further endoscopy. When the cleanliness of the transverse colon is poor, then stopping further endoscopy is considered.

1. Introduction

Numerous patients who suffered from colon diseases benefited from the invention of colonoscopy; the cleanliness of intestinal preparation has always been the key issue while the colonoscopy technology is developing. The scale of evaluation of intestinal cleanliness has also emerged continuously, with its advantages, disadvantages, and scope of application [1–4]. The Boston Bowel Preparation Scale (BBPS) [5] proposed by the Boston University has been proven to have high reliability and validity [6–8], and is widely used by digestive endoscopy workers in Europe, Korea, China, etc. It is also an indicator of intestinal cleanliness observed after a retrospective view and is related to the quality of the intestinal examination.

However, in real-world clinical scenarios, initial bowel examinations often observed that patients with unsatisfactory bowel preparation, which is difficult to decide whether to continue the colonoscopy observations or not. It might turn out that bowel preparations were worse, making colonoscopy examinations meaningless, but this would not be 100% true until the statistical confirmation. As of today, there is no literature to analyze the clinical correlation of cleanliness in various regions of the intestine, so it is still confusing for endoscope physicians.

Based on these premises, this article aims to investigate the relationship and provide a clinical statistical basis for the above confusion. To fulfill this goal, we will use BBPS, which has proven to be highly reliable and widely used in China, to analyze the correlation of intestinal cleanliness with a large number of samples in a random manner. By using these statistics, we will get reliable results as follows.

2. Materials and Methods

2.1. Research Object. The study was conducted from February 2017 to October 2019. The subjects of the study were
patients who underwent colonoscopy in the Gastroenterology Hangzhou First People’s Hospital affiliated to the Zhejiang University School of Medicine. Patients without abdominal surgery used polyethylene glycol electrolyte powder for intestinal preparation and had complete records and attached complete intestinal pictures were included in the study.

2.2. Research Methods

2.2.1. Ethics. All methods and data analyses were approved by the local ethics board of Hangzhou First People’s Hospital, Zhejiang University School of Medicine.

2.2.2. The Boston Bowel Preparation Scale. The Boston Bowel Preparation Scale (BBPS; suggested pronunciation “bee-bops”) was developed to limit interobserver variability in the rating of bowel preparation quality, while preserving the ability to distinguish various degrees of bowel cleanliness: right (right) lateral colon (including cecum and ascending colon), transverse colon (including liver and spleen flex), and left (left) colon (including descending colon, sigmoid colon, and rectum). According to different bowel preparation cleanliness, different evaluation scores are given in Figure 1. Each region of the colon receives a “segment score” from 0 to 3, and these scores total the total BBPS score from 0 to 9. Thus, the maximum clean BBPS score for a colon without any residual liquid is 9 and the minimum BBPS score for no colon preparation is 0. If the endoscopes discontinue surgery due to inadequate preparation, then any non-visualized proximal segments 0 points are assigned.

2.2.3. Statistical Analysis. SPSS 22.0 statistical software was used for data analysis. The continuous measurement data was expressed as $x \pm s$. The $t$-test was used for comparison between groups. The count data was expressed by the number of cases or rate (%), and the $\chi^2$ test was used for comparison between groups. $P < 0.05$ was considered statistically significant; the ROC curve test was used to predict the accuracy of the inference, and the cross-tab test was performed based on Youden’s index to calculate sensitivity, specificity, misdiagnosis rate, missed diagnosis rate, positive predictive value, negative predictive value, etc. Indicators inferred prediction accuracy; Pearson’s correlation analysis of colon cleanliness in each region and the use of GraphPad Prism 7.00 mapping make the results more intuitive.

2.2.4. Type of Study. The clinical data of patients who underwent colonoscopy in the Gastroenterology of Hangzhou First People’s Hospital affiliated to the Zhejiang University School of Medicine, from February 2017 to October 2019, were analyzed retrospectively. The cleanliness of intestinal area and the correlation between intestinal cleanliness of 1739 patients in this period were analyzed.
3. Result

3.1. Patient Characteristics. A total of 1739 cases were included in the study, including 853 males (49.1%) and 886 females (50.9%) (age 52 ± 14 years old, maximum age 87 years, minimum age 12 years; see Table 1).

The BBPS overall score was 87 ± 12.34, and in the right side colon (2.04 ± 0.84), and transverse colon (2.25 ± 0.68), and left colon (2.48 ± 0.64) were statistically significant (P < 0.05); from the ileocecal to the anus, the intestinal cleanliness shows a gradual optimization trend, as shown in Figure 2.

4. Correlation between Colon Cleanliness in Various Regions

Pearson’s correlation analysis was performed using the right side colon, transverse colon, and left colon scores. The correlation between right and left was r = 0.529, P ≤ 0.001 < 0.05. There can be a significant positive correlation between left and right; there is a significant positive correlation between adjacent colon regions (see Table 2).

5. Prediction of Colon Cleanliness by Region

The right side colon score was predicted and grouped. The grouping standard is BBPS: a score of 0-1 and a value of 0 mean “poor intestinal preparation,” a score of 2-3 and a value of 1 mean “intestinal tract is ready,” the ROC test is performed with the left colon score and the transverse colon score, and the transverse colon (AUC = 0.809) is compared to the left colon score (AUC = 0.735) The case of predicting the right side colon has a better accuracy (see Figure 3 and Table 3).

Left colon predicts transverse colon cleanliness, AUC = 0.814, with good accuracy (see Figure 4 and Table 4). In this test, the score corresponding to the maximum value of Youden’s index is also the value of the cut-off point of 2.5. Therefore, after grouping according to 2.5, crosschecking is performed between the regions, and then the sensitivity, specificity, misdiagnosis rate, and missed diagnosis are calculated by the formula. Indicators such as rate, positive predictive value, and negative predictive value indicate that the transverse colon predicts that the right side of the colon is relatively clean, while the left colon predicts that the right side of the colon is not highly accurate (see Table 5).

6. Comparison of Intestinal Cleanliness Scores by Age

The 1739 patients in this study were divided into 105 youth (0–14 Y), 1091 middle aged (15–59 Y), and 543 elderly (60-100 Y). The BBPS scores were 7.01 ± 1.74 points, 6.76 ± 1.93 points, and 6.74 ± 1.80 points, the total score and the cleanliness score of each area were compared, and the differences were not statistically significant (P > 0.05) (see Tables 6 and 7).
better tolerability and less frequent adverse events demon-

stration shows sodium picosulfate/magnesium citrate with
widely used at home and abroad [18], and recent meta-

intestinal cleansers, polyethylene glycol is still the most
with good intestinal cleanliness [16, 17]. In the choice of
selection of ADR, even the best new foundation must be achieved
extent [10].

laxatives, the intestinal cleanliness is improved to some
by active oral intestinal laxative preparations, in recent years, passive intestinal clean-

ing methods such as Aquanet EC-2000 have also been devel-
oped, with effects similar to oral sodium matrine sulfate and
mannitol oral solutions [20, 21]. In actual clinical work, the
preparation situation is not optimistic. Despite several inter-
ventions, only two-thirds of inpatients achieve adequate colon preparation before colonoscopy [22]. Even if you enter
the sigmoid colonoscopy, you will find that the bowel prepa-
ration is poor (BBPS 0-1). Continued endoscopy can increase
the risk of complications of colonoscopy, such as bleeding
and perforation. Abandoning endoscopy will increase the
risk of missed diagnosis of intestinal lesions, and there are
potential legal risks. Therefore, this study provides the theo-
retical basis for digestive endoscopy doctors to suspend the
operation, which can make the decision reasonable.

Our study found that the overall score of the BBPS score
was 6.77 ± 1.88, which was slightly higher than that of the
BBPS Research Center data of Boston Medical Center
(6.2 ± 1.5) [5], which indicates that we have a good prepara-
tion for intestinal cleanliness in the endoscopic center. Intes-
tinal cleanliness in the three regions is as follows: right side,
2.04 ± 0.84 points; transverse, 2.25 ± 0.68 points; and left
(colon), 2.48 ± 0.64 points. There were significant differ-
ences among regions (P < 0.05). From the ileocecal part to
anus, there is a trend of gradual optimization, and the differ-
ence is statistically significant. This shows that the cleanliness
of the intestinal tract often deteriorates gradually after endos-
copy, which may lead to failure to continue endoscopy or
ineffective endoscopy and increase the risk of complications
of intestinal examination. The results can guide the subse-
quent correlation study of colon cleanliness in each region.
At the same time, the intestinal preparation requires that
the excrement should be clear water or yellow without slag.
This study can prove the accuracy of this viewpoint.

Our study found that there was a positive correlation
between the cleanliness of the adjacent intestines in the three
areas, which was consistent with the routine examination
logic. At the same time, it was found that there was a positive
relation between the right colon and the left colon, which
were a non-adjacent colon. This indicated that there was a
theoretical support for predicting the intestinal preparation
of the right colon (examination endpoint) through the left
colon (examination starting point). Therefore, ROC curve
was formed, and it was concluded that the accuracy of pre-
dicting the right colon (AUC = 0.809) was higher than that
of the left colon (AUC = 0.735), which was consistent with
the examination logic with high routine proximity accuracy.
Based on Youden’s index, the cross-tabulation test showed
that the accuracy of left colon intestinal cleanliness predic-
tion for right colon intestinal cleanliness was not high, while
the accuracy of transverse colon prediction for right colon
was high. Therefore, the conclusion of this study is that the
accuracy of colon cleanliness prediction in adjacent areas is
high, and there is an error in the accuracy of colon cleanliness
prediction on the right side using the left colon. In clinical
operation, the endoscope cannot be stopped because the
intestinal cleanliness difference (BBPS 0-1 score) is found in
the anus, i.e., the intestinal cleanliness difference on the right
side is inferred, but if the intestinal cleanliness difference on
the transverse colon (BBPS 0-1 score) is found, the endo-
scope can be stopped.

At the same time, due to the large sample size and large
age span of the sample study, we stratified according to

7. Discussion

Intestinal preparation plays an important role in colonos-
copy and is the key to ensuring high-quality completion of
colonoscopy. The 2019 European Digestive Endoscopy
Society Guidelines for Intestinal Preparation [9] pointed out
that poor bowel preparation could lead to poor bowel prepa-
ration. The detection rate of intestinal adenoma decreased,
the failure rate of ileocecal bronchoscopy increased, the
patient’s pain increased, and the medical expenses were
increased. The Boston Intestinal Cleanliness Scale score was
also mentioned, and the total score is considered qualified if
it is greater than or equal to 6.

Even if clinicians use many methods to improve intesti-
nal cleanliness, such as WeChat, SMS, phone reminder, and
laxatives, the intestinal cleanliness is improved to some
extent [10–15]. Because intestinal cleanliness is the founda-
tion of ADR, even the best new foundation must be achieved
with good intestinal cleanliness [16, 17]. In the choice of
intestinal cleansers, polyethylene glycol is still the most
widely used at home and abroad [18], and recent meta-
analysis shows sodium picosulfate/magnesium citrate with
better tolerability and less frequent adverse events demon-
strated non-inferior bowel cleaning efficacy than that of the
polyethylene glycol [19]. In addition to active oral intestinal
laxative preparations, in recent years, passive intestinal clean-
ing methods such as Aquanet EC-2000 have also been devel-
oped, with effects similar to oral sodium matrine sulfate and
mannitol oral solutions [20, 21]. In actual clinical work, the

![ROC curve](image_url)

**Figure 3:** Cleanliness prediction of the right segment of the colon. Diagonal segments are produced by ties.
Table 3: Area under the predicted curve of the right side colon (AUC).

<table>
<thead>
<tr>
<th>Test result variable</th>
<th>Area</th>
<th>Standard error</th>
<th>Progressive sig.</th>
<th>Asymptotic 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower limit</td>
</tr>
<tr>
<td>Transverse</td>
<td>0.809</td>
<td>0.011</td>
<td>0.000</td>
<td>0.787</td>
</tr>
<tr>
<td>Left</td>
<td>0.735</td>
<td>0.014</td>
<td>0.000</td>
<td>0.707</td>
</tr>
</tbody>
</table>

Test result variable: transverse, left. There is at least one knot between the positive and negative actual state groups. Statistics may vary.

Figure 4: Prediction of the cleanliness of the transverse colon. Diagonal segments are produced by ties.

Table 4: Area under the predicted curve of the transverse colon (AUC).

<table>
<thead>
<tr>
<th>Test result variable</th>
<th>Area</th>
<th>Standard error</th>
<th>Progressive sig.</th>
<th>Asymptotic 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower limit</td>
</tr>
<tr>
<td>Left</td>
<td>0.814</td>
<td>0.018</td>
<td>0.000</td>
<td>0.779</td>
</tr>
</tbody>
</table>

Test result variable: left has at least one knot between the positive and negative actual state groups. Statistics may vary.

Table 5: Cross-sectional test between each colon area.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>L prediction R</th>
<th>Item result (%)</th>
<th>L prediction T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>43.67</td>
<td>66.16</td>
<td>37.10</td>
</tr>
<tr>
<td>Specificity</td>
<td>100.00</td>
<td>74.31</td>
<td>99.52</td>
</tr>
<tr>
<td>False positive rate (misdiagnosis rate)</td>
<td>0.00</td>
<td>25.69</td>
<td>0.48</td>
</tr>
<tr>
<td>False negative rate (missing rate)</td>
<td>56.33</td>
<td>33.84</td>
<td>62.90</td>
</tr>
<tr>
<td>Authenticity (accuracy)</td>
<td>57.79</td>
<td>68.20</td>
<td>44.57</td>
</tr>
<tr>
<td>Prevalence</td>
<td>74.93</td>
<td>74.93</td>
<td>88.04</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>100.00</td>
<td>88.50</td>
<td>99.82</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>37.26</td>
<td>42.35</td>
<td>17.69</td>
</tr>
<tr>
<td>Positive LR</td>
<td>—</td>
<td>257.53</td>
<td>7716.79</td>
</tr>
<tr>
<td>Negative LR</td>
<td>56.33</td>
<td>45.54</td>
<td>63.20</td>
</tr>
</tbody>
</table>
age group, 105 young people (0Y-29Y), 1091 middle aged (30Y-59Y), and 543 elderly (60-100Y). By comparing the differences in intestinal cleanliness among different age groups, we found that the differences were not statistically significant, suggesting that the data in this study is highly reliable and the results are not affected by age differences.

There are still some deficiencies in this study. The main reason is that endoscopy doctors in this center did not test
the reliability of the Boston scoring scale. The sample size of this study is relatively small and is a single-center study. Therefore, the conclusion of this study should be tested by big data in the later period.

In summary, the intestinal cleanliness gradually deteriorates from the direction of endoscope insertion. The intestinal preparation requires that the excreta be clear water or yellow without slag. The reliability of using the left colon intestinal cleanliness difference to predict the right side poor is not good, and the endoscope should be continued. The transverse colon intestinal cleanliness difference can be considered to stop the endoscope insertion.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

We have no competing interests.

Acknowledgments

This study has come from the support of all colleagues in the Gastroenterology of Hangzhou First People’s Hospital affiliated to Zhejiang University School of Medicine, especially from Professor Zhang Xiaofeng and my mentor Professor Yang Jianfeng for their guidance.

References


