

## Colonoscopy can miss diverticula of the left colon identified by barium enema

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### Abstract

**AIM:** To identify the diagnostic value of colonoscopy for diverticulosis as determined by barium enema.

**METHODS:** A total of 65 patients with hematochezia who underwent colonoscopy and barium enema were analyzed, and the diagnostic value of colonoscopy for diverticula was assessed. The receiver operating characteristic area under the curve was compared in relation to age ( $< 70$  or  $\geq 70$  years), sex, and colon location. The number of diverticula was counted, and the detection ratio was calculated.

**RESULTS:** Colonic diverticula were observed in 46 patients with barium enema. Colonoscopy had a sensitivity of 91% and specificity of 90%. No significant dif-

ferences were found in the receiver operating characteristic area under the curve (ROC-AUC) for age group or sex. The ROC-AUC of the left colon was significantly lower than that of the right colon (0.81 vs 0.96,  $P = 0.02$ ). Colonoscopy identified 486 colonic diverticula, while barium enema identified 1186. The detection ratio for the entire colon was therefore 0.41 (486/1186). The detection ratio in the left colon (0.32, 189/588) was significantly lower than that of the right colon (0.50, 297/598) ( $P < 0.01$ ).

**CONCLUSION:** Compared with barium enema, only half the number of colonic diverticula can be detected by colonoscopy in the entire colon and even less in the left colon.

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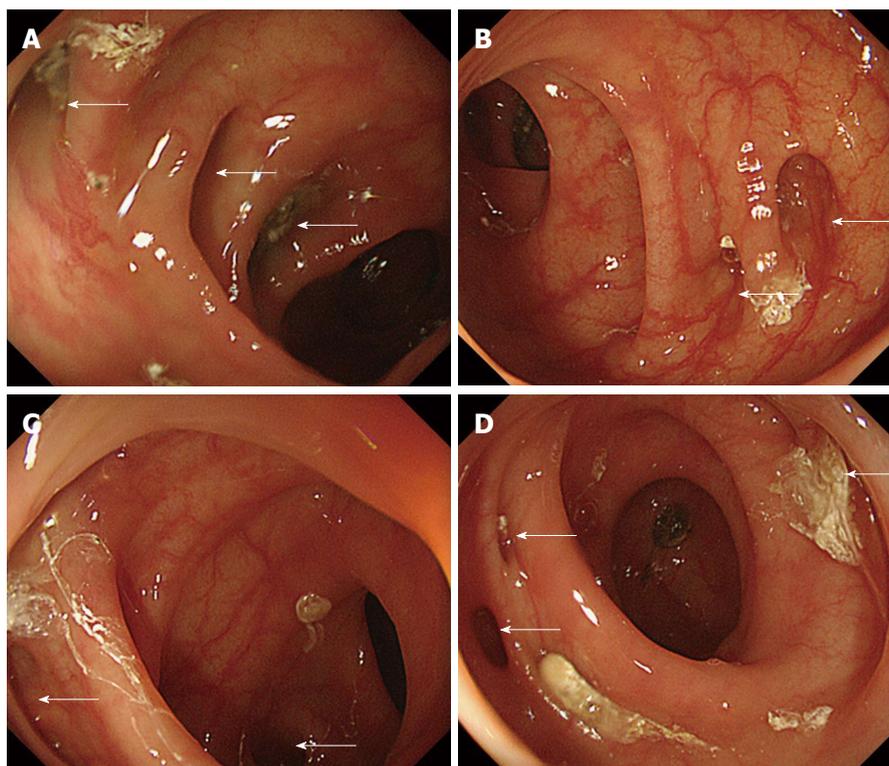
**Key words:** Colonoscopic diagnosis; Colonic diverticulosis; Colonic diverticular bleeding; Barium enema; Receiver operating characteristic area under the curve

**Core tip:** We identified the diagnostic value of colonoscopy for colonic diverticulosis as determined by barium enema. The only half the number of colonic diverticula can be detected in the entire colon and even less in the left colon. By revealing the diagnostic value of colonoscopy for colonic diverticula, it may contribute to further therapeutic interventions strategies for the treatment of colonic diverticular disease.

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### INTRODUCTION

Colonic diverticulosis is a common disease that occurs



**Figure 1** Colonic diverticula in the left colon on endoscopy. The colon location was classified as the right colon (cecum and ascending and transverse colon) or the left colon (descending colon and sigmoid colon). A: Sigmoid-descending colon junction; B: Proximal sigmoid colon; C: Sigmoid top; D: Distal sigmoid colon. Arrows show colonic diverticula determined by colonoscopy.

in approximately one third of the population older than 45 years and in up to two thirds of the population older than 85 years in the United States<sup>[1,2]</sup>. In Asia, the prevalence of colonic diverticula is 28% and is increasing<sup>[3]</sup>. The prevalence of diverticulitis and diverticular bleeding has also been increasing<sup>[4]</sup>.

Diverticulosis of the colon is often diagnosed during routine screening colonoscopy. In clinical practice, severe diverticulosis anatomically increases the risk of perforation because of fixed angulations, deep folds, and peristalsis of the colon<sup>[5-7]</sup>. Therefore, the true lumen can sometimes be confused with diverticulosis when multiple large diverticular orifices are encountered. Moreover, circular muscular atrophy with severe diverticula can also create deep crevices in the colonic wall, making polyp detection more difficult<sup>[8]</sup>. Colonoscopy is usually used to diagnose colonic diverticular bleeding<sup>[9,10]</sup>. Identification of the bleeding site of colonic diverticula on colonoscopy enables endoscopic treatment with clips<sup>[11]</sup>, epinephrine injection, heat probing<sup>[10]</sup>, and ligation<sup>[12]</sup>. These modalities can circumvent complications such as hemorrhagic shock and rebleeding<sup>[10]</sup>. Therefore, identifying the diagnostic value of colonoscopy for colonic diverticula is important but has remained unclear.

By contrast, barium enema can clearly detect colonic diverticula<sup>[5]</sup> because barium fills the entire colon in diverticulosis. Consequently, we evaluated the diagnostic value of colonoscopy for colonic diverticula in patients with hematochezia who underwent both colonoscopy and barium enema. In addition, differences in diagnostic value with regard to age, sex, and colonic location were assessed.

## MATERIALS AND METHODS

### Patients

We retrospectively selected 436 patients from the electronic endoscopic database who had undergone colonoscopy for hematochezia from 2008 to 2011 at the National Center for Global Health and Medicine. We excluded 355 patients who did not receive barium enema and 16 who did not undergo total colonoscopy. After exclusion, 65 patients were enrolled.

### Colonoscopic assessment

Intestinal lavage for endoscopic examination was performed using 2 L of a solution containing polyethylene glycol. An electronic video endoscope (high-resolution scope, model CFH260; Olympus Optical, Tokyo, Japan) was used for the diagnosis of hematochezia by expert endoscopists. The results of the endoscopic examination were saved in the electronic database. Upon detecting diverticula, the location (cecum and ascending, transverse, descending, and sigmoid colon) and number were recorded (Figure 1).

### Barium enema examination

Barium enema is a diagnostic imaging modality of the colon that has been used previously to evaluate diverticula<sup>[13,14]</sup>. Barium enema was indicated for patients with colorectal cancer or to prevent recurrence of colonic diverticular bleeding<sup>[6,15,16]</sup> and was performed within three days after colonoscopy. Intestinal lavage for the barium enema examination was performed using sodium picosulfate (1 mL) and magnesium citrate (250 mL) the day be-



**Figure 2** Colonic diverticula in the left colon on radiography with barium enema. The colonic location was classified as the right colon (cecum and ascending and transverse colon) or the left colon (descending colon and sigmoid colon).

for the assessment and bisacodyl suppositories (10 mg) on the day of assessment. The barium solution (200-400 mL) was 70%-200%. Barium was injected from the anus to the cecum in all patients to visualize the entire colon tract in different positions. The presence, location, and number of colonic diverticula were determined by radiography (Figure 2).

**Ethics**

This study was approved by the institutional review board of the National Center for Global Health and Medicine (approval number: 765).

**Statistical analysis**

The gold standard for detecting colonic diverticula is barium enema radiography. To identify the diagnostic value of colonoscopy for colonic diverticula, we calculated the sensitivity, specificity, receiver operating characteristic area under the curve (ROC-AUC), positive likelihood ratio (PLR), and negative likelihood ratio (NLR). In a subgroup analysis, we assessed the diagnostic value of colonoscopy with regard to age, sex, and colonic location. Subjects were divided into two groups according to age:  $\geq 70$  years old and  $< 70$  years old. The colon location was classified as the left colon (descending and sigmoid colon) and the right colon (cecum and ascending and transverse colon). Differences in the ROC-AUCs were compared in relation to age, sex, and location.

The receiver operating characteristic is a diagnostic test that presents its results as a plot of sensitivity *vs* 1-specificity (often called the false-positive rate). The ROC-AUC indicates the probability of a measure or predicted risk being higher for patients with disease than for those without disease<sup>[17-19]</sup>. The detection ratio (colonoscopy/barium enema) of colonic diverticula was assessed and also compared between the left and right colon using the  $\chi^2$  test. A *P* value  $< 0.05$  was considered significant. All statistical analyses were performed using Stata version 10 software (StataCorp, College Station, TX, United States).

**RESULTS**

**Patient characteristics**

Sufficient imaging by colonoscopy and barium enema

Sex (male/female)	40/25
Mean age (IQR)	73 (66-78)
Median duration (IQR) between the onset of hematochezia and colonoscopy	4 (2-8)
Cause of hematochezia	
Colonic diverticular bleeding	30
Colon cancer (cecum/ascending/transverse/sigmoid colon)	19 (3/8/2/6)
Rectal cancer	14
Unknown	2

IQR: Interquartile range.

was obtained for all patients due to adequate stool cleaning. No patients experienced perforation during air insufflation to expand the colon, and none showed a worsened condition such as abdominal pain or nausea after colonoscopy or barium enema. The median age was 73 years, and many patients were elderly men (Table 1). The causes of hematochezia included colonic diverticular bleeding, colonic cancer, and rectal cancer.

**Diagnostic value of colonoscopy for colonic diverticula**

Colonic diverticula were observed in 46 patients (71%) using barium enema. The number of colonic diverticula identified by colonoscopy was 486, whereas that by barium enema was 1186. Colonoscopy had a sensitivity of 91%, a specificity of 90%, a PLR of 8.7, and an NLR of 0.097 for the diagnosis of colonic diverticula (Table 2).

In a subgroup analysis, no significant differences were found in the ROC-AUCs between age groups and sex. However, the ROC-AUC of the left colon was significantly lower than that of the right colon (0.96 *vs* 0.81, *P* = 0.02).

**Detection ratio (colonoscopy/barium enema) of colonic diverticula**

The detection ratio for the entire colon was 0.41 (486/1186) (Figure 3). The detection ratio for the left colon (0.32, 189/588) was significantly lower than that of the right colon (0.50, 297/598) (*P*  $< 0.01$ ).

**DISCUSSION**

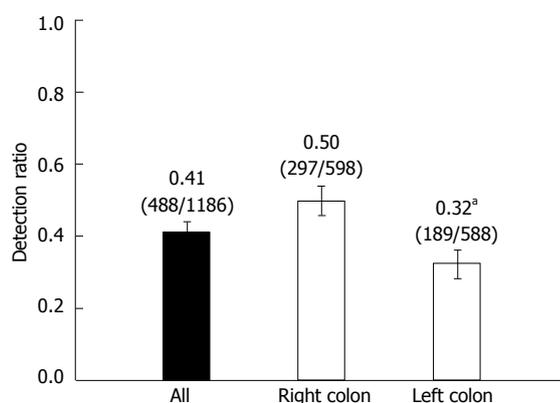
No previous study has reported the diagnostic value of colonoscopy for colonic diverticulosis. Colonoscopy has been used worldwide as a standard tool for the screening of colonic cancer and the diagnosis of other lower gastrointestinal tract diseases<sup>[20]</sup>. Colonic diverticulosis is a common disease in Asia, Europe, and the United States<sup>[2]</sup>, occurring in approximately one third of the population older than 45 years<sup>[1]</sup>. The prevalence of colonic diverticulosis increases with age, and serious complications with diverticulitis and diverticular bleeding have been on the rise in recent years<sup>[1]</sup>. To address these problems, we investigated the diagnostic value of colonoscopy in colonic diverticulosis.

While the detection rate for diverticula with colo-

**Table 2** Diagnostic value of colonoscopy for colonic diverticula in 65 patients

Number <sup>1</sup>	Sens, % (95%CI)	Spec, % (95%CI)	LR (+) (95%CI)	LR (-) (95%CI)	ROC-AUC (95%CI)	P value
All (44/21)	91 (79-98)	90 (67-99)	8.7 (2.3-32)	0.097 (0.038-0.52)	0.90 (0.82-0.99)	
Age (yr)						
< 70 (18/9)	90 (67-99)	88 (47-100)	7.2 (1.1-45)	0.12 (0.032-0.46)	0.89 (0.74-1)	
≥ 70 (26/12)	93 (76-99)	91 (59-100)	10 (1.6-66)	0.082 (0.021-0.31)	0.92 (0.82-1)	0.68
Sex						
Female (13/12)	100 (72-100)	86 (57-98)	5.8 (1.8-18)	0.05 (0.0033-0.76)	0.93 (0.83-1)	
Male (31/9)	89 (73-97)	100 (48-100)	11 (0.74-150)	0.14 (0.056-0.33)	0.94 (0.89-1)	0.47
Location						
Right colon (40/25)	95 (84-99)	96 (79-100)	23 (3.4-156)	0.051 (0.013-0.20)	0.96 (0.90-1)	
Left colon (26/39)	66 (49-80)	96 (81-100)	18 (2.6-123)	0.36 (0.23-0.56)	0.81 (0.73-0.90)	0.02

<sup>1</sup>With/without diverticulosis. P values were calculated using the receiver operating characteristic curve area under the curve (ROC-AUC) for comparisons in this category. Sens: Sensitivity; Spec: Specificity; LR: Likelihood ratio.



**Figure 3** Detection ratio (colonoscopy/barium) of colonic diverticula in 65 patients. Right colon denotes the cecum, ascending colon, and transverse colon. Left colon denotes the descending colon and sigmoid colon. <sup>a</sup>P < 0.05 by  $\chi^2$  test. Error bars show the 95%CI of the detection ratio.

noscopy was acceptable, our results showed that the diagnostic value decreased significantly for detection in the left colon. In addition to detecting the presence of diverticula, we counted the number of diverticula in 65 patients and found that colonoscopy detected only one third of the diverticula in the left colon identified by barium enema. The detection rate for diverticula by colonoscopy was higher than that reported previously<sup>[21]</sup>, and this is presumably because a different group of patients was used in this study; Song *et al.*<sup>[21]</sup> enrolled patients screened by colonoscopy, while the present study investigated patients with hematochezia.

We believe these results were influenced greatly by anatomical factors of the colon, and we thus propose two hypotheses for the poor diagnostic value of colonoscopy in the left colon. First, the diameters of the ascending and transverse colons on the right side of the body are reportedly 4.9 and 4.2 cm, respectively<sup>[22]</sup>. However, the diameters of the descending and sigmoid colons constituting the left colon are both 3.3 cm, notably narrower than the right colon<sup>[22]</sup>. Because of the narrower diameter, the field of view in colonoscopy is expected to be lower in the left colon, making the detection of diverticula more difficult.

In addition, the sigmoid colon, which accounts for one third of the left colon and is not supported by the mesentery, bends sharply<sup>[22]</sup>. Intestinal bending not only creates blind spots for colonoscopy but also complicates distinguishing diverticula from the true lumen<sup>[5,23]</sup>, thus greatly affecting the accuracy of diagnosis with colonoscopy.

Although the present study also investigated other factors such as age and sex in addition to anatomical factors, no significant differences were observed. Sadahiro *et al.*<sup>[22]</sup> investigated age- and sex-related differences in the surface area of the large intestine with barium enema. They found that the mean surface area of the large intestine in men aged  $\geq 70$  years was 1569.4 cm<sup>2</sup>, while that in men aged  $\leq 69$  years was 1566 cm<sup>2</sup>, with no significant difference. The mean surface area in women aged  $\geq 70$  years was 1575.4 cm<sup>2</sup>, while that in women aged  $\leq 69$  years was 1628 cm<sup>2</sup>. These results support our finding that the anatomy of the colon is rarely influenced by age or sex. In a previous study on the detection of colonic polyps, it was reported that the degree of bowel preparation<sup>[24]</sup> and observation time<sup>[25]</sup> were associated with missed colonic polyps. Although we were unable to evaluate this issue in the present study, we plan to investigate it in the future.

We believe the present findings will influence the diagnosis and treatment of colonic diverticulosis and complications including diverticular bleeding. Knowing the areas of the colon where it is easy to overlook the presence of diverticula or to confuse a diverticulum with a true lumen may help endoscopists perform proper screening colonoscopy and reduce the risk of perforation<sup>[5,7,23]</sup>. It is important to identify the stigmata of recent hemorrhage (SRH) when diagnosing or treating diverticular bleeding<sup>[23]</sup>. To date, diagnosis and treatment have been conducted under the assumption that colonoscopy will identify all colonic diverticula regardless of the anatomical factors of the colon. However, our study showed that colonoscopy detected only 32% of all diverticula in the left colon. This suggests that the SRH were overlooked, which is supported by a previous study reporting that colonoscopy identified the SRH in only one third of patients with colonic diverticular bleeding<sup>[23]</sup>.

Here, we evaluated colonic diverticula using static

images, but it proved difficult to determine the exact number of colonic diverticula using these images. We therefore plan to perform a prospective study of colonic diverticula using video of live endoscopy procedures.

In the present study, the diagnostic value of colonoscopy for the left colon was relatively low, revealing only one third of the diverticula observed by barium enema. The diagnosis and treatment of colonic diverticulosis and complications, such as diverticular bleeding, should be performed with consideration of the findings of this study.

## COMMENTS

### Background

Colonic diverticulosis is a common disease, and the prevalence of diverticulitis and diverticular bleeding has been increasing. Colonoscopy is useful for diagnosing colonic diverticula and colonic diverticular bleeding. However, the diagnostic value of colonoscopy has remained unclear.

### Research frontiers

Colonoscopy is often used to diagnose colonic diverticular bleeding and therefore can be useful for subsequent endoscopic treatment if the bleeding site can be identified. Determining the diagnostic value of colonic diverticula is important. In this study, the authors revealed the diagnostic value of colonic diverticula by colonoscopy.

### Innovations and breakthroughs

Previous reports have highlighted the prevalence of diverticula by barium enema. The authors identified the diagnostic value of colonoscopy for colonic diverticulosis as determined by barium enema. The only half the number of colonic diverticula can be detected in the entire colon and even less in the left colon.

### Applications

By revealing the diagnostic value of colonoscopy for colonic diverticula, the results of this study may contribute to future therapeutic intervention strategies for the treatment of patients with colonic diverticular disease.

### Terminology

The receiver operating characteristic is a diagnostic testing modality that presents its results as a plot of sensitivity vs 1-specificity (often called the false-positive rate). The receiver operating characteristic area under the curve indicates the probability of a measure or predicted risk being higher for patients with disease than for those without disease.

### Peer review

The authors evaluated the diagnostic value of colonic diverticula by colonoscopy compared with barium enema. This study revealed that threefold more diverticula can be detected by barium enema than by colonoscopy.

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