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Original Article

Diagnostic value of capsule endoscopy and double-balloon enteroscopy in small bowel diseases

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Abstract: Objective: To analyze the diagnostic value of capsule endoscopy (CE) and double-balloon enteroscopy (DBE) in small bowel diseases. Methods: The clinical data of 134 cases of CE and 109 cases of DBE examined in our gastroscopy room from January 2016 to December 2019 were retrospectively analyzed. The two groups of patients were compared as to disease diagnostic rate, examination time, examination tolerance, and incidence of adverse reactions. Results: The two groups showed no significant difference in general data (all $P>0.05$). The DBE group showed a higher disease diagnostic rate than the CE group ($P<0.05$). Significantly higher rates of suspected intestinal bleeding were observed in the DBE group than those of the CE group ($P<0.05$), but no significant differences were found in the diagnosis of unexplained abdominal pain, abdominal distension, and others (all $P>0.05$). The DBE group required a longer examination time, and had a higher incidence of adverse reactions, and a lower examination tolerance than the CE group ($P<0.05$). Conclusion: Both DBE and CE are effective in small bowel diseases diagnoses, but DBE demonstrated greater potential in diagnosing small bowel bleeding.

Keywords: Capsule endoscopy, double-balloon enteroscopy, diagnosis, small bowel bleeding

Introduction

The lack of specific clinical manifestations of small bowel diseases often causes delayed treatment, which seriously compromises the prognosis [1-3]. The small bowel is anatomically located between the stomach and the colon, and its structure prevents traditional invasive imaging or observation [4, 5]. Currently, capsule endoscopy (CE) and double-balloon enteroscopy (DBE) allow real-time imaging of small bowel lesions [6-8]. As a non-invasive method, CE contributes to the observation of the whole small bowel mucosa and intestinal peristalsis, with a high diagnostic accuracy. However, it fails to perform pathologic diagnoses of intestinal specimens. Compared to traditional enteroscopy, DBE allows navigation of the entire small bowel from either an oral or rectal approach. The balloons can grip sections of the small bowel and pleat it over the endoscope to perform diagnosis or treatment. Currently, the clinical application of CE and DBE in the diagnosis and treatment of small bowel diseases remains controversial [8]. CE is recommended as a first-line diagnosis method for small bowel diseases in some research, while DBE has also been reported as a preferred diagnostic tool for patients with small bowel diseases with abdominal pain or diarrhea [9]. Accordingly, this study retrospectively analyzed patients with small bowel diseases treated with CE or DBE in our hospital and systematically evaluated the application efficiency of CE and DBE.

Data and methods

General data

Clinical data of patients who underwent CE or DBE in *First Affiliated Hospital of Soochow University* from January 2016 to December 2019 were retrospectively analyzed. Among them, 134 patients (79 males and 55 females) received CE, and 109 patients (60 males and 49 females) with a mean age of (54.52±11.95) years old underwent DBE. The inclusion criteria were as follows: Patients with gastrointestinal

bleeding of unknown causes, abnormal imaging results of small bowel suggested by other examination methods, chronic diarrhea, abdominal pain, or suspected gastrointestinal tumor. The exclusion criteria were as follows: Patients with CE contraindications such as dysphagia and suspicious intestinal stenosis, patients with severe anemia, patients with suspected intestinal perforation, fistula or obstruction or other intolerance to CE, patients at a risk of anesthesia that prevents DBE, and patients who were unable to complete intestinal preparation or receive DBE due to small bowel obstruction.

Ethics statement

The study was ethically approved by the ethics committee of the *First Affiliated Hospital of Soochow University*, with Approved No. of 2021-LSP254. All patients and their families signed informed consent before enrollment.

Examination methods

After admission, a physical examination was performed on all patients with suspected small bowel diseases, and their general clinical data were collected. CE or DBE was adopted to observe the small intestine. Biopsy tissues were collected from the patients undergoing DBE to clarify the etiology if necessary.

CE was applied with an OMOM capsule gastrointestinal endoscopy system to examine the small bowels. Only easily digestible food such as porridge was allowed two days before the examination, and liquid food one day before the examination. Intestinal preparation: 2000 mL polyethylene glycol 6 hours before enteroscopy and 30 mL simethicone 1 hours before enteroscopy. The next day, after the bowel preparation, the imaging equipment was prepared as required. The patients were instructed to swallow the capsule endoscope and were allowed to perform free movement after real-time monitoring showed its entry into the duodenum. Patients were allowed to take a small amount of food before removal of the capsule endoscope and were required to keep away from environments that may interfere with the image transmission of the equipment such as strong magnetic fields and strenuous activities. The capsule position was monitored in real time. When the capsule entered the ileocecal valve or the capsule power was depleted, the recording device was removed and the patients were diagnosed by two senior attending physicians. After the examination, the patients were required to examine the feces carefully for the presence of the capsule endoscope. Patients without excretion of capsule endoscope found within 14 days returned to the hospital for X-ray examination to determine the retention of CE and were given proper treatment if necessary.

For DBE, the small bowels of patients were examined with a double-balloon enteroscope (EN-580T, Fujinon, Japan). Enteroscopy was performed through the oral approach for cases with possible lesions in the upper part of the small bowel and through the rectal approach for cases with lesions in the lower part of the small bowel. The patients had a low-residue diet on the day before the examination and were fasted after 8:00 in the night before the examination. 3,000 mL polyethylene glycol combined with 30 mL simethicone was taken to clean the bowels 6-10 hours before the examination. On the next day, the surgery was performed by an endoscopist under general anesthesia, including lens insertion, hook pulling, and air pump control, to complete the abdominal small bowel examination.

Outcome measures and evaluation of examination effects

Assessment of disease detection rate: After examination, the detection rate of the patients was calculated based on the clinical application guide of small intestine capsule endoscopy [9]. Positive was considered: confirmed bleeding caused by ulcers and tumors. Negative was considered: no obvious lesions. Suspiciously positive was considered intestinal polyps and others that could not cause bleeding. The lesion detection rate was (positive and negative)/total number of cases ×100%.

Examination time, tolerance score and image quality: The examination time of CE and DBE was recorded, and the patient's tolerance to DBE was scored by 1-5 points according to the patient's chief complaint during examination, with 1 point for intolerance and five points for complete tolerance.

Bubble score: 0 points: An entire field of vision without bubble; 1 point: The entire field of view

Table 1. Comparison of general clinical data between the two groups

Groups	CE group (n=134)	DBE group (n=109)	t/χ^2	P
Male [cases (%)]	79 (58.96)	60 (55.05)	0.375	0.542
Age (years old)	53.97±10.82	57.08±15.42	-1.814	0.071
Course of disease (days)	24.67±5.92	23.95±6.07	0.932	0.352
Heart disease (Yes/No)	52/82	44/65	0.061	0.080
Cerebrovascular disease (Yes/No)	26/108	31/78	2.734	0.098
Hypertension (Yes/No)	64/70	55/54	0.175	0.676
Diabetes (Yes/No)	25/109	18/91	0.190	0.663
Smoke (Yes/No)	31/103	28/81	0.213	0.644

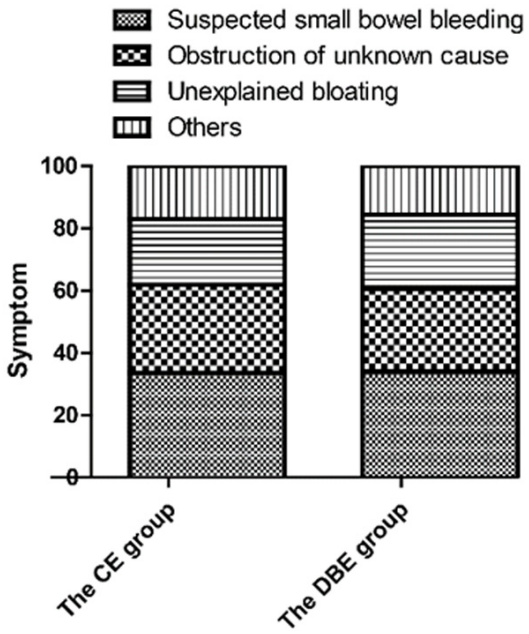

Figure 1. Clinical symptom composition rate in the two groups.

was occupied by <1/3; 2 points: The entire field of view was occupied by 1/3-2/3; 3 points: The entire field of view was occupied by >2/3. Cleanliness score: 0 points: clear digestive fluid and clear visual field; 1 point: The digestive fluid was slightly cloudy without hindering observation; 2 points: The digestive fluid was slightly cloudy and hindered observation (the observation of obvious lesions was not affected, and non-obvious lesions could not be determined); 3 points: Poor visual field due to turbid digestive fluid. The average score was calculated according to the total integral of bubbles in the selected images of the small intestine.

Record of adverse reactions: The incidence of adverse reactions in all patients was recorded, including endoscopic retention, bleeding, perforation, and infection.

Statistical analysis

The measured data in a normal distribution were expressed as mean ± standard deviation, and the enumerated data were expressed as cases (%). General clinical data and post-examination complications of the two groups were compared using the t-test and Chi-square test, respectively. SPSS 20.0 was used for the above statistical analyses. GraphPad Prism 7 (GraphPad Software, San Diego, USA) was used for image rendering. $P<0.05$ indicated a significant difference.

Results

Comparison of general clinical data between the two groups

The general clinical data of the patients are shown in **Table 1**. There was no statistical difference in age, gender, and course of disease between the two groups. The ratio of heart disease, cerebrovascular disease, hypertension, diabetes, and smoking between the two groups were comparable (all $P>0.05$). The symptoms of patients mainly included suspected small bleeding, obstruction of unknown cause, and unexplained bloating. There was also no statistical difference in the composition ratio of primary symptoms between them ($P>0.05$, **Figure 1**).

Comparison of disease detection rate and disease diagnosis results between the two groups

The disease detection rates and total small bowel examination completion rate of the CE

Table 2. Comparison of lesion detection rates between the two groups

Group	n	Lesion detection rate	Total small bowel examination completion rate
CE group	134	108 (80.60%)	125 (93.28%)
DBE group	109	102 (93.58%)	92 (84.40%)
χ^2		8.630	3.370
P		0.003	0.066

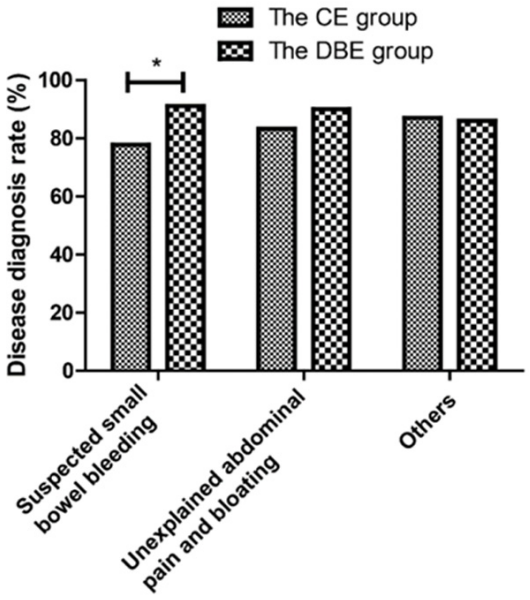

Figure 2. Diagnostic rates of double-balloon enteroscopy and capsule endoscopy under different examination indications, *P<0.05.

group were 80.60% (108/134) and 93.58% (102/109) respectively, and for the DBE group these were 93.28% (125/134) and 84.40% (92/109) respectively. The Chi-square test results showed that the disease detection rates of the DBE group were higher than those of the CE group (P<0.05), while the total small bowel examination completion rate was comparable (P>0.05), as shown in **Table 2**.

Further analysis was conducted on the diagnostic results of patients with suspected intestinal bleeding and abdominal pain or abdominal distension of unknown causes in the two groups. The results are shown in **Figure 2**. The Chi-square test indicated significantly higher diagnostic rates of suspected intestinal bleeding in the DBE group than the CE group (P< 0.05), but no significant differences were found in the diagnosis of unexplained abdominal pain, abdominal distension, and others (all P>0.05).

Comparison of diagnostic results from suspected intestinal bleeding, abdominal pain, and abdominal distension of different causes between the two groups

The diagnostic results of patients with suspected intestinal bleeding and abdominal pain or abdominal distension of unknown causes in the two groups were further analyzed, as shown in **Table 3**. Chi-square test showed that in the diagnosis of suspected intestinal bleeding, the detection rates of the DBE group were higher than those of the CE group (P<0.05), but in the diagnosis of unexplained abdominal pain and abdominal distension, there were no significant differences in detection between the two groups (P>0.05). The images of CE and DBE manifested dominant hemorrhagic spots and ulcerative lesions in the small bowel, respectively, and the image clarity from DBE was higher than that from CE. Typical imaging results of CE and DBE in the detection of intestinal bleeding and unexplained abdominal pain are shown in **Figure 3**.

Comparison of examination time and tolerance between the two groups

The examination time and tolerance of patients in the groups are shown in **Figure 4**. The examination time and examination tolerance score of the CE group were (572.85±32.58) and (4.52±0.26) respectively, and for the DBE group these were (112.02±11.25) and (3.78± 0.26) respectively. t-test showed that the average examination time of the CE group was longer than that of the DBE group (P<0.05). However, the tolerance score of the CE group was also higher than that of the DBE group (P<0.05).

Comparison of the image quality transmitted from the capsule endoscope

In the CE group, the bubble score was (2.03± 0.54) and cleanliness score was (1.46±0.43); in the DBE group, the bubble score was (1.92±0.63) and the cleanliness score was (1.59±0.51). The scores of bubble and cleanliness were similar between the two groups (all P>0.05), shown in **Table 4**.

Incidence of adverse reactions and treatment success rate in the two groups

The adverse reactions of the two groups are shown in **Table 5**. There were 3 cases of mild

Table 3. Comparison of diagnostic results of suspected intestinal bleeding and unexplained abdominal pain and distension

	CE group	DBE group	χ^2	P
Suspected small intestinal bleeding	n=45	n=37	4.597	0.032
Vascular	12 (26.67)	6 (16.22)		
Inflammation	8 (17.78)	10 (27.03)		
Ulcerative	6 (13.33)	9 (24.32)		
Tumor space-occupying	5 (11.11)	13 (35.16)		
Diverticulum	3 (6.67)	1 (2.70)		
Others	1 (2.22)	2 (5.41)		
Diagnostic rate	77.77%	91.11%		
Unexplained abdominal pain and distension	n=66	n=55	0.295	0.587
Vascular	17 (25.75)	12 (21.82)		
Inflammation	25 (37.88)	14 (25.45)		
Ulcerative	10 (15.15)	8 (14.55)		
Tumor space-occupying	2 (3.03)	1 (21.82)		
Diverticulum	0 (0.00)	3 (5.45)		
Others	1 (1.52)	2 (3.64)		
Diagnostic rate	83.33%	92.73%		

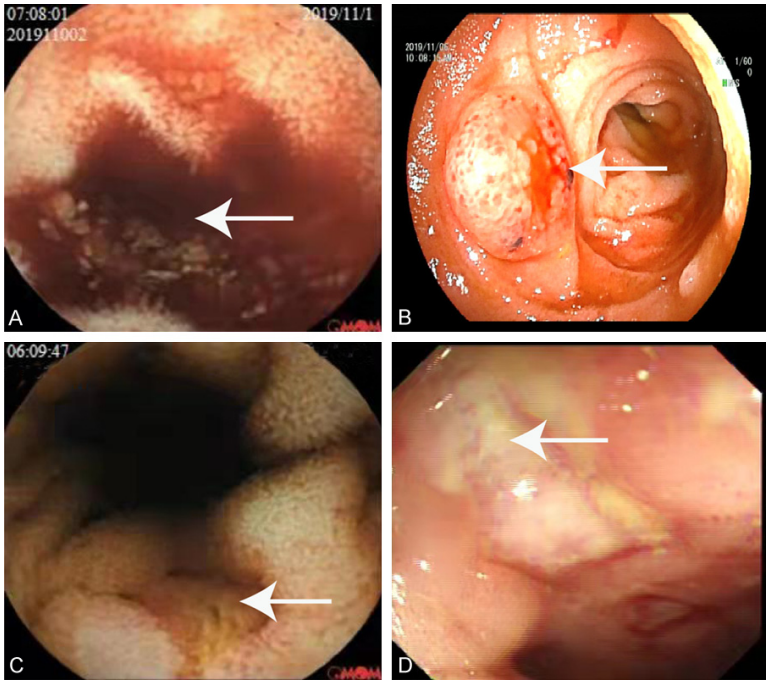

Figure 3. Typical imaging results of CE and DBE in the detection of intestinal bleeding and unexplained abdominal pain (white arrow is the lesion site). A. CE results in small bowel bleeding; B. DBE result of small bowel bleeding; C. CE results in abdominal pain due to small intestinal ulcers; D. DBE results in abdominal pain caused by a small intestinal ulcer.

diarrhea, 5 cases of flatulence, and 10 cases of sore throat in the DBE group, presenting a total adverse reaction rate of 16.51% (18/109). There were 1 case of intestinal obstruction and 2 cases of delayed evacuation in the CE group, presenting a total adverse reaction rate of 2.24% (3/134). Chi-square analysis showed that the incidence of adverse reactions in the DBE group was significantly higher than that in the CE group (P<0.001).

Discussions

The application of DBE and CE markedly improves the diagnosis of small bowel diseases [10, 11]. However, the occult occurrence of small bowel disease with varying clinical symptoms complicates the identification of appropriate tests for patients. Improper examination method will delay the treatment and increase the medical cost. Therefore, in this study, the diagnostic rates of DBE and CE under different clinical symptoms were systematically evaluated, and indicators including examination time and patient examination tolerance were ana-

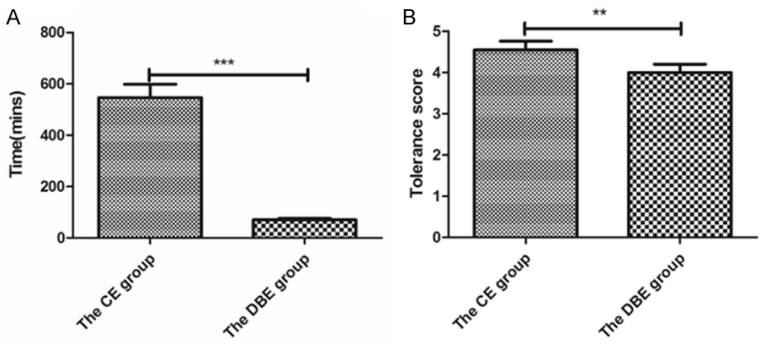

Figure 4. Comparison of examination time (A) and examination tolerance score (B) between the two groups, $^{**}P<0.01$, $^{***}P<0.001$.

Table 4. Comparison of image quality transmitted from the capsule endoscope

Group	n	Bubble score	Cleanliness score
CE group	134	2.03±0.54	1.46±0.43
DBE group	109	1.92±0.63	1.59±0.51
χ^2		1.535	1.096
P		0.126	0.274

lyzed to provide a theoretical basis for the selection of clinical examination methods for patients with small bowel diseases.

Diseases such as Crohn's enteritis and small intestinal tumor can trigger clinical symptoms such as persistent intestinal bleeding, abdominal pain, and abdominal distension [12-15]. Herein, the proportion of patients requiring small intestinal imaging due to the primary symptoms of persistent intestinal bleeding, abdominal pain, and distension exceeded 50%. Prior research has found that the overall disease detection rate of DBE and CE in hemorrhagic small bowel diseases is 50-89%, and the diagnostic efficacy of DBE is superior to that of CE [16, 17]. Consistent with previous studies, our results showed that the DBE was superior to CE in the diagnostic rate of small bowel bleeding (91.11% *vs.* 71.77%), but had no advantages over CE in the detection of abdominal distension and abdominal pain. There were no significant differences in the proportion of diagnostic results of the two methods, as the advancement of capsule endoscope in the intestinal tract is passively dependent on the peristalsis and contraction of the gastrointestinal tract, with an uneven advancement speed, which causes a blind area in the field of vision. Furthermore, overt hemorrhage in the small bowel also disrupts the CE's field of vision and the etiologic diagnosis. DBE is performed under artificial operation, and the entire small bowel is detected through the oral and rectal approaches. Repeated observation and biopsy of the lesional site were also available, which markedly improves the diagnosis of small bowel bleeding. In addition, DBE allows for the direct treatment of benign lesions such as ulcers and polyps, which offers additional advantages over CE. Therefore, DBE shows greater potential in the clinical diagnosis and treatment of patients with suspected small bowel bleeding.

Patients' tolerance to examination and potential complications may also interfere with clinical decisions. CE has complications, high examination tolerance, and a markedly low probability of capsule endoscope retention [18, 19]. DBE is an invasive procedure that requires both intravenous anesthesia and inflation for a full small bowel examination, which may increase the incidence of complications such as intestinal flatulence, mild diarrhea, and laryngeal pain, and even aspiration, bleeding, and perforation in severe cases [20]. Previous studies even reported cases of pancreatitis and splenic rupture in DBE [21, 22]. In reality, carbon dioxide gas pump with reduced intestinal pressure was used to avoid serious complications. Nevertheless, a higher incidence of adverse reactions was observed in the DBE group than in the CE group, and the patient tolerance in the DBE group was lower than that in the CE group. However, the DBE group had a significantly shorter examination time than the CE group, which ensures a better recovery. The above results suggest a promising tolerance for both DBE and CE. However, as an invasive examination, DBE requires highly experienced doctors with high operating proficiency. Therefore, patients' subjective appeals and conditions should be taken into consideration to select appropriate examination methods. There were still some limitations to this study. This study was a single-center retrospective study with a small sample size and insufficient reliability and validity and has drawn significant conclu-

Table 5. Comparison of incidence of adverse reactions

Group	n	Mild Diarrhea	Flatulence	Sore Throat	Delayed Evacuation	Intestinal Obstruction	Total Adverse Reactions
DBE group	109	3	5	10	0	0	16.51% (18/109)
CE group	134	0	0	0	2	1	2.24% (3/134)
X^2							15.514
P							<0.001

sions with limited enrollments. A randomized controlled study with larger sample size is required in future studies.

In summary, both DBE and CE are effective in small bowel diseases diagnoses, and DBE demonstrated greater potential in diagnosing small bowel bleeding.

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Disclosure of conflict of interest

None.

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