

Comparison of patients' tolerance between computed tomography enterography and double-balloon enteroscopy

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Background: Computed tomography enterography (CTE) and double-balloon enteroscopy (DBE) are widely used in diagnosis of small bowel diseases. Both of these examinations bring discomfort to patients. The aim of this study was to compare patients' tolerance and preference between CTE and DBE.

Methods: From August 1, 2014 to December 31, 2016, patients with suspected or known small bowel diseases who underwent both CTE and DBE were prospectively enrolled in our study. They were asked to fill out a questionnaire evaluating discomfort of the procedure after each examination.

Results: One hundred and seven patients completed our study. Abdominal distension, painfulness, tenesmus, general discomfort, prolonged duration, difficulty in completing the test, and discomfort after the examination were significantly lower with CTE than with DBE ($P < 0.001$, respectively). Mannitol intake (47.7%), bowel preparation (31.9%), and radiation exposure (15.0%) were regarded as the three most intolerable burdens in CTE. Painfulness (38.3%), bowel preparation (26.2%), and invasiveness (16.8%) were considered as the three most unacceptable parts of DBE. More patients (61.7%) preferred to repeat CTE rather than DBE ($P < 0.001$).

Conclusion: Compared to DBE, CTE was a more tolerable and less burdensome examination and enjoyed higher preference by most patients.

Keywords: computed tomography enterography, double-balloon enteroscopy, tolerance and preference

Introduction

Study of the small bowel is considered difficult due to its length, special anatomy, and location, thus the diagnosis and management of patients with suspected small bowel diseases are quite challenging for gastroenterologists. With the rapid development of endoscopic techniques and radiologic approaches, there are multiple new diagnostic tools available for doctors to better evaluate the small bowel, among which include computed tomography enterography (CTE) and double-balloon enteroscopy (DBE).¹⁻⁴

CTE is a recently introduced technique for small intestine disorders. Patients who undergo CTE ingest a certain amount of neutral contrast agents before the procedure, which enables luminal distention and allows a better view of the entire small bowel.^{5,6} Moreover, besides its noninvasiveness, fast collecting and image reconstructing, CTE provides the visualization of the whole abdomen including the extraintestinal lesions. The main limitations of CTE are radiation exposure and inability of biopsy.⁷⁻⁹

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DBE, which was developed by Yamamoto et al,¹⁰ provides us a clearer and more direct visualization of the small intestine. Moreover, biopsy and treatment such as hemostasis, polypectomy, and dilation are possible during DBE. However, invasiveness, prolonged time duration, difficulty in completing the whole small bowel examination, and additional need for an assistant are the main disadvantages of DBE.^{7,8,11,12}

Both CTE and DBE could bring discomfort to patients during the procedure.^{13,14} Therefore, patients' acceptance and tolerance should be taken into account when doctors choose the diagnostic tools, especially for those individuals suffering from chronic diseases such as inflammatory bowel disease (IBD) who need repeated examinations during their follow-ups.^{13,15} Up to now, some studies have been raised to compare the diagnostic yield between CTE and DBE.^{7,16} However, as far as we know, there is no study comparing patients' acceptance between these two procedures. This study was aimed to assess patients' tolerance and preference between CTE and DBE.

Methods

Patients

From August 1, 2014, to December 31, 2016, patients with suspected or known small bowel diseases who underwent both CTE and DBE (via anal) examinations were prospectively enrolled in our study in Ruijin Hospital. Exclusion criteria included allergies to contrast media (previous adverse events during iodinated contrast media injection), severe small bowel stricture or obstruction, recent use of antiplatelet or anticoagulant drugs, pregnancy or breast-feeding, electrolyte disturbance, inability to understand or finish the questionnaires independently, other serious diseases.

This study was approved by the ethics committee of Ruijin Hospital affiliated to School of Medicine Shanghai Jiao Tong University, and written informed consent was signed by each patient or parent or legal guardian (for patients <18 years old).

Methods

All patients first underwent CTE examination and then DBE examination via anal. The time interval between CTE and DBE was restricted to less than 2 months. Patients were asked to fill in a questionnaire 1 week after each examination.

CTE procedure

Bowel cleansing was performed with a single dose of 2 L PEG electrolytes powder on the day before the examination.

Patients were asked to drink 2,000 mL 2.5% iso-osmotic mannitol solution approximately 45 minutes before the examination in order to obtain optimal small bowel distension. Before the examination, 20 mg of anisodamine was administered intramuscularly to reduce bowel peristalsis. CTE scan was performed on a 64-slice multi-slice multi-detector computed tomography scanner (GE Medical Systems, Milwaukee, WI, USA) from the porta hepatis to pubic symphysis. After plain computed tomography (CT) scanning, patients were injected with nonionic contrasts (Ioversol, Optiray 320; Tyco Healthcare, Montreal, Canada) via the antecubital vein at a rate of 3 to 4 mL/sec and a total of 90 to 120 mL (1.5 mL/kg of body weight). Then arterial phase and portal venous phase imaging was performed. Images were reconstructed using the workstation (ADW4.2 and ADW4.4).

DBE procedure

After bowel preparation with PEG electrolytes powder (the same regimen as used in CTE) and 20 mg injection of anisodamine, DBE was performed using a video endoscope (Fujinon EN-450P5/20; Fujinon Inc., Saitama, Japan) with a working length of 200 cm and an overtube of 145 cm in length, both of which have balloons at their distal ends. All the DBE examinations were performed by the same endoscopist via the anal approach with conscious sedation (injection of 10 mg diazepam intramuscularly before the procedure). The indication to stop insertion was discovery of the lesion or difficulty in further advancing.

Questionnaires

One week after CTE, the patients were asked to complete the first questionnaire (Figure S1) composed of two parts. The first part included eleven questions assessing patients' acceptance of CTE, including discomfort of the bowel preparation, nausea and vomiting during the test, abdominal distension during the examination, pain during the procedure, tenesmus during the test, discomfort of the entire examination, time duration of the entire procedure, difficulty in completing the test, discomfort several days after the examination, time until stool consistency recovery, and cost of the test. Each question used a 4-point scale. For example, "Did you feel uncomfortable during the bowel preparation in the CTE examination?": 1 (none), 2 (mild), 3 (moderate), 4 (severe). The second part was a question to patients to list the three most unacceptable burdens of CTE. The six selectable options were discomfort of the bowel preparation, ingesting large amount of mannitol, radiation exposure, prolonged time duration of the test, high cost, and slow recovery of bowel function after the exam.

One week after DBE, the patients were asked to fill in another questionnaire (Figure S2), which consisted of three parts. The first part was the same eleven questions evaluating the individual's tolerance of the test as used after CTE. The second part asked the patients to list the three most intolerable burdens of DBE. The seven selectable options were discomfort of the bowel preparation, abdominal distension during the procedure, painfulness during the test, invasiveness to the bowel, prolonged duration of the test, high cost, and slow recovery of bowel function after the exam. The third part was a direct question concerning the preference of CTE or DBE ("If you need a repeated small bowel examination, which test would you like to choose, CTE or DBE?").

Statistical analysis

Student's *t*-test was used for comparison of the tolerability between CTE and DBE. The results were considered significant at $P < 0.05$. The reasons of non-acceptance of CTE and DBE are briefly described using frequencies and percentages. Data analysis was conducted using SPSS 21.0 (IBM Corporation, Armonk, NY, USA).

Results

During our research, 115 patients underwent both CTE and DBE examinations in our hospital. Among them, six patients refused to answer our questionnaires and another two patients did not fill out the questionnaires completely. Finally, 107 patients completed our study, whose demographic and disease-related characteristics are summarized in Table 1.

The scores of the eleven evaluated items about burdens of CTE and DBE are described in Figure 1 (A–K). The average score of each item and comparison between the two procedures are shown in Table 2. For abdominal distension, painfulness, tenesmus, general discomfort, prolonged time duration, difficulty in completing the test and discomfort after the examination, patients reported DBE more burdensome than CTE ($P < 0.001$, respectively). However, regarding other items including bowel preparation, nausea and vomiting, time until stool consistency recovery and cost of the test, patients reported similar acceptance ($P > 0.05$, respectively).

Patients' feedback on why they did not like CTE is shown in Table 3. It was shown that the most intolerable burden of CTE reported was mannitol intake (47.7%). The next important reason was discomfort of the bowel preparation (31.9%), and the third important item was radiation exposure

Table 1 Demographic and disease-related characteristics

Variable	n (%)
Sex	
Male	83 (77.6)
Female	24 (22.4)
Age (years)	
<18	6 (5.6)
18–60	96 (89.7)
>60	5 (4.7)
Education	
<High school	46 (43.0)
≥High school	61 (57.0)
Marital status	
Married	92 (86.0)
Single	15 (14.0)
Symptom	
Abdominal pain	69 (64.5)
Diarrhea	64 (59.8)
Perianal lesions	37 (34.6)
Weight loss	31 (29.0)
Gastrointestinal bleeding	23 (21.5)
Mild small bowel obstruction	11 (10.3)
Mass	6 (5.6)
Diagnosis	
Crohn's disease	44 (41.1)
No positive findings	15 (14.0)
Nonspecific enteritis	14 (13.1)
Follicular lymphoid hyperplasia	8 (7.5)
Meckel's diverticulum	6 (5.6)
Gastrointestinal stromal tumor	4 (3.7)
Small bowel adenoma/adenocarcinoma	4 (3.7)
Lymphoma	3 (2.8)
Behcet's disease	3 (2.8)
Capillary malformation	2 (1.9)
Intestinal tuberculosis	2 (1.9)
Cryptogenic multifocal ulcerous stenosing enteritis	2 (1.9)

(15.0%). High cost (3.7%), prolonged time duration of the test (0.9%), and slow recovery of bowel function after the exam (0.9%) were ranked the fourth to sixth items in reported importance. Feedback on why patients did not like DBE is shown in Table 4, pain during the test (38.3%) was considered as the most burdensome by the majority of patients. The second most unacceptable item was discomfort of the bowel preparation (26.2%). Invasiveness to the bowel (16.8%) was the third most important reason responsible for intolerability of DBE, while abdominal distension during the procedure (11.2%) was ranked fourth. Furthermore, the fifth to seventh in reported importance were high cost (5.6%), prolonged time duration of the test (0.9%), and slow recovery of bowel function after the exam (0.9%).

As shown in Figure 2, 66 (61.7%) patients preferred CTE if a repeated small bowel examination was needed, as compared to 41 (38.3%) patients who preferred DBE ($P < 0.001$).

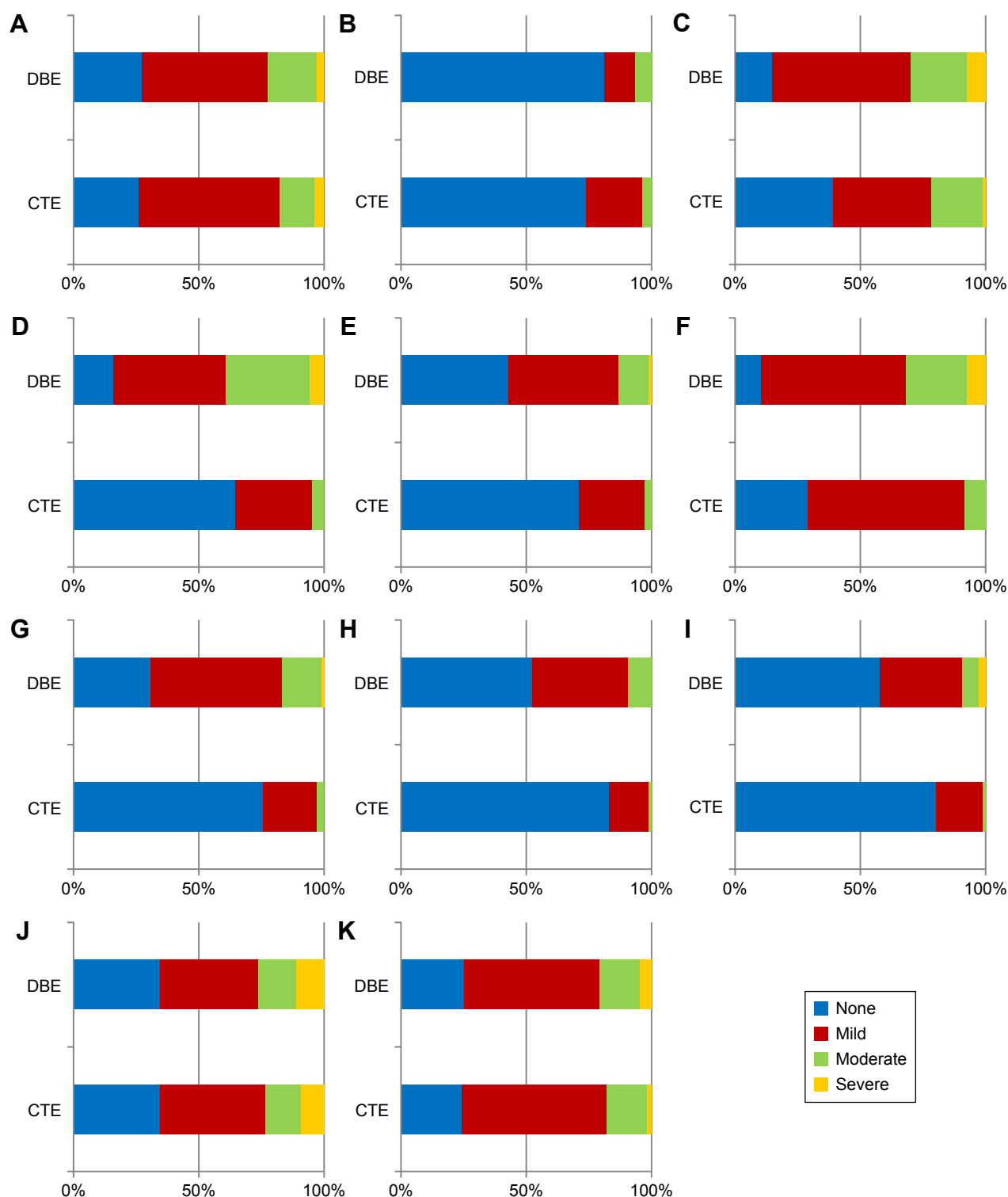


Figure 1 Tolerability of the eleven evaluated burdens of CTE and DBE on a 4-point scale.

Notes: (A) Bowel preparation; (B) nausea and vomiting; (C) abdominal distension; (D) painfulness; (E) tenesmus; (F) general discomfort; (G) prolonged time duration; (H) difficulty in completing the test; (I) discomfort after the examination; (J) time until stool consistency recovery; (K) cost.

Abbreviations: CTE, computed tomography enterography; DBE, double-balloon enteroscopy.

Discussion

When comparing different small bowel imaging techniques, most of the previous researches focused on their diagnostic efficacy.^{7,17–19} However, patients' tolerance of each procedure

should also be taken into consideration, especially when repeated examinations are needed, as tolerance and acceptance of a certain examination may impact their choice and adherence to later follow-ups.²⁰

Table 2 Comparison of patients' tolerance between CTE and DBE

Item	CTE n=107	DBE n=107	P-value
Bowel preparation	1.95±0.75	1.98±0.77	0.657
Nausea and vomiting	1.32±0.54	1.25±0.57	0.225
Abdominal distension	1.83±0.78	2.22±0.79	<0.001
Painfulness	1.40±0.58	2.29±0.80	<0.001
Tenesmus	1.32±0.53	1.71±0.71	<0.001
General discomfort	1.79±0.58	2.29±0.75	<0.001
Prolonged time duration	1.27±0.51	1.87±0.70	<0.001
Difficulty in completing the test	1.18±0.41	1.57±0.66	<0.001
Discomfort after the examination	1.21±0.43	1.54±0.74	<0.001
Time until stool consistency recovery	1.98±0.93	2.03±0.98	0.387
Cost	1.95±0.69	2.00±0.78	0.459

Abbreviations: CTE, computed tomography enterography; DBE, double-balloon enteroscopy.

To our knowledge, this is the first study to directly compare CTE and DBE in terms of patient burden and tolerance. Our study showed most patients who had experienced both examinations preferred CTE rather than DBE. Patients considered DBE significantly more burdensome than CTE in terms of abdominal distension, painfulness, tenesmus, general discomfort, prolonged time duration, difficulty in completing the test, and discomfort after the examination.

In a previous study of comparison among DBE, capsule endoscopy (CE), and magnetic resonance (MR) enteroclysis, the results showed CE was significantly favored over the other two procedures in terms of bowel preparation, entire discomfort during the examination, time duration, and swallowing the capsule (compared to insertion of the tube/scope).¹⁵ MR enteroclysis was preferred to DBE with respect to bowel preparation, painfulness, and burden of the entire examination while DBE was more tolerable than MR enteroclysis for insertion of the scope and procedure duration. In our study, most of the patients complained about bowel preparation, painfulness, and general discomfort during the DBE procedure. Besides, they found DBE

Table 3 Rating of the importance of different burdens of CTE examination

Item	Most important n (%)	Second important n (%)	Third important n (%)
Mannitol intake	51 (47.7)	35 (32.7)	11 (10.3)
Bowel preparation	34 (31.9)	32 (30.0)	19 (17.8)
Radiation exposure	16 (15.0)	23 (21.5)	30 (28.0)
Cost	4 (3.7)	10 (9.3)	25 (23.4)
Prolonged time duration	1 (0.9)	4 (3.7)	9 (8.4)
Slow bowel function recovery	1 (0.9)	3 (2.8)	13 (12.1)

Abbreviation: CTE, computed tomography enterography.

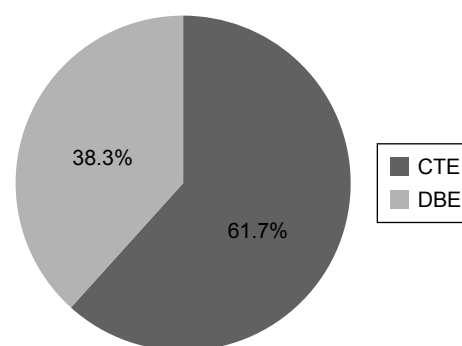
Table 4 Rating of the importance of different burdens of DBE examination

Item	Most important n (%)	Second important n (%)	Third important n (%)
Painfulness	41 (38.3)	23 (21.5)	9 (8.4)
Bowel preparation	28 (26.2)	14 (13.1)	22 (20.6)
Invasiveness	18 (16.8)	31 (29.0)	19 (17.8)
Abdominal distension	12 (11.2)	14 (13.1)	20 (18.7)
Cost	6 (5.6)	9 (8.4)	12 (11.2)
Prolonged time duration	1 (0.9)	13 (12.1)	14 (13.1)
Slow bowel function recovery	1 (0.9)	3 (2.8)	11 (10.3)

Abbreviation: DBE, double-balloon enteroscopy.

a quite time-consuming examination which was difficult to accomplish. Previous research¹⁵ also suggested that CE and MR enteroclysis provided clearer pre-exam explanation of the modality than DBE, which probably could be explained by the fact that DBE is more unpredictable in advance. In their study, patients considered CE as the most preferable, followed by MR enteroclysis as the second, and DBE as the last. Our research got a similar result – fewer patients would be willing to repeat DBE rather than CTE.

Research of tolerance between other small bowel diagnostic techniques is also lacking. One study compared MR enterography (MRE) and MR enteroclysis. Patients ingested the contrast material either orally or through a nasogastric catheter. Abdominal pain and discomfort were reported to be lower with MRE than with MR enteroclysis, and more patients found it acceptable to repeat MRE.²¹ Another study compared MRE with CE, indicating that CE was less burdensome in pre-exam discomfort, during-exam discomfort, nausea, vomiting, bloating, and abdominal pain.¹³ They also found MRE was associated with a specific adverse event – claustrophobia. Consequently, CE was a better tolerated and more preferable test than MRE.

**Figure 2** Proportions of patients' preference for CTE or DBE.

Abbreviations: CTE, computed tomography enterography; DBE, double-balloon enteroscopy.

A systematic review and meta-analysis of preference for colonoscopy versus computerized tomographic colonography (CTC) showed colonoscopy was graded more uncomfortable by patients and CTC was preferred over colonoscopy in most of the studies.²² Similar to CTC, MR colonography was also more tolerable than colonoscopy.²³ Patients in our study experienced less burden from CTE examination compared to DBE examination and regarded CTE as a more favorable procedure. It seems that imaging examinations have a higher acceptance than endoscopic modalities regardless of small bowel examination or colon disease screening.^{24,25}

In the present study, we found patients' main dissatisfactions about CTE were ingestion of a large amount of oral contrast agent, bowel preparation, and radiation exposure. Previous research evaluating tolerance of oral contrast agents with different quantity and osmolality in CTE test indicated patients preferred the ingestion of 1,000 mL solution to the 1,500 mL solution, while no statistically significant differences in mean small bowel diameter were seen between both contrast agents.²⁶ For this reason, a lower quantity of solution ingestion should be considered to raise patients' tolerance if similar small bowel distension could be achieved. Patients using sodium picosulfate with magnesium citrate (SPMC) for bowel preparation were less likely to have abdominal fullness, pain, nausea or vomiting, and reported SPMC to be more palatable compared to PEG, while no difference was shown among the two groups with respect to bowel cleansing grade (Ottwa Scale).²⁷ In our study, all the patients used PEG for bowel preparation. In the future, we may try other types of bowel preparation to help reduce patients' burden in small bowel diagnostic examinations. It was reported that many IBD patients received high-dose radiation exposure with cumulative effective dose >50 mSv.^{28–32} About half of the participants in our cohort were Crohn's disease patients and may need small bowel examination again in the future. MRE and trans-abdominal ultrasonography (US) would be alternative radiation-free imaging strategies, due to their equivalent diagnostic accuracy, better tolerance, and cost effectiveness.^{33–38}

As for DBE, patients' major complaints were painfulness, bowel preparation, and invasiveness. Since, occasionally, position changes were needed during the DBE procedure for smoother intubation, patients in our study were all provided with conscious sedation rather than general anesthesia. Nevertheless, painfulness still remained challenging for most of our patients. Therefore, general anesthesia could be taken into account in our future DBE examinations to reduce

painfulness.^{39–44} It is inevitable that DBE examinations are invasive, which some of our patients found unacceptable. CE is a potential alternative because of its noninvasive quality and better tolerance, while having a comparable diagnostic yield with DBE in small bowel diseases.¹⁸ But risk of capsule retention should be taken into account.^{45,46}

There are several limitations to our study. First, we did not include CE in our research, which is considered as a small bowel examination with good tolerance and preference.^{13,15} This is because CE is an examination of high cost in our country and not covered by Chinese medical insurance. In further studies, we can add CE and other modalities such as MRE and US into comparison. Second, we needed the results of CTE examination to decide which patients were suitable for via anal DBE examinations. So, the order of CTE and DBE in our study was fixed, which might have had an effect on patients' acceptance of these two procedures. Besides, we did not include via oral DBE in our research because of the small sample size. Only 21 patients received both CTE and via oral DBE examinations during our research time. Comparison of tolerance between via anal DBE, via oral DBE, and CTE will be done in our future studies when we have a larger sample size. Furthermore, the interval between these two tests was 2 months. During this interval, patients' disease activity might have been different, which also could have impacted their tolerance of the examinations. Finally, we found that although DBE was a more burdensome test than CTE, there were still 38.3% of patients in our cohort who preferred to choose DBE next time. The reason why they had a preference for DBE should be studied in further research.

Conclusion

Our study found CTE was more tolerable and less burdensome than DBE in many aspects and preferred by more patients. Mannitol intake, bowel preparation, and radiation exposure were the three main reasons for patients' intolerance of CTE while painfulness, bowel preparation, and invasiveness were the three major causes of patients' burden in DBE. Further modifications of procedures should be made in order to improve patients' tolerance and acceptance of both CTE and DBE.

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Author contributions

All authors contributed toward data analysis, drafting and critically revising the paper, and agreed to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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Supplementary materials

Questionnaires used in our study comparing tolerance between computed tomography enterography and double-balloon enteroscopy.

Part 1

1. Did you feel uncomfortable during the bowel preparation in the CTE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
2. Did you feel nausea or vomiting during the CTE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
3. Did you feel discomfort of abdominal distension during the CTE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
4. Did you feel painful during the CTE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
5. Did you feel discomfort of tenesmus during the CTE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
6. How did you feel the general discomfort of the CTE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
7. Did you feel time duration of the CTE examination long?
☐ None
☐ Mild
☐ Moderate
☐ Severe
8. Did you feel difficult to complete the CTE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe

Figure S1 (Continued)

9. Did you feel uncomfortable in the several days after the CTE examination?

☐ None

☐ Mild

☐ Moderate

☐ Severe

10. Did you feel the recovery of stool consistency slow after the CTE examination?

☐ None

☐ Mild

☐ Moderate

☐ Severe

11. Did you feel CTE examination expensive?

☐ None

☐ Mild

☐ Moderate

☐ Severe

Part 2

Please list the three most intolerable burdens of CTE examination from below

☐ Bowel preparation

☐ Ingesting large amount of mannitol

☐ Radiation exposure

☐ Prolonged time duration

☐ High cost

☐ Slow recovery of bowel function after the exam

Most intolerable burden: _____

Second intolerable burden: _____

Third intolerable burden: _____

Figure S1 Questionnaire A.

Abbreviation: CTE, computed tomography enterography.

Part 1

1. Did you feel uncomfortable during the bowel preparation in the DBE examination?

☐ None

☐ Mild

☐ Moderate

☐ Severe

2. Did you feel nausea or vomiting during the DBE examination?

☐ None

☐ Mild

☐ Moderate

☐ Severe

3. Did you feel discomfort of abdominal distension during the DBE examination?

☐ None

☐ Mild

☐ Moderate

☐ Severe

Figure S2 (Continued)

4. Did you feel painful during the DBE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
5. Did you feel discomfort of tenesmus during the DBE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
6. How did you feel the general discomfort of the DBE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
7. Did you feel time duration of the DBE examination long?
☐ None
☐ Mild
☐ Moderate
☐ Severe
8. Did you feel difficult to complete the DBE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
9. Did you feel uncomfortable in the several days after the DBE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
10. Did you feel the recovery of stool consistency slow after the DBE examination?
☐ None
☐ Mild
☐ Moderate
☐ Severe
11. Did you feel DBE examination expensive?
☐ None
☐ Mild
☐ Moderate
☐ Severe

Figure S2 (Continued)

Part 2

Please list the three most intolerable burdens of DBE examination from below?

- ☐ Bowel preparation
- ☐ Abdominal distension
- ☐ Painfulness
- ☐ Invasiveness to the bowel
- ☐ Prolonged time duration
- ☐ High cost
- ☐ Slow recovery of bowel function after the exam

Most intolerable burden: _____

Second intolerable burden: _____

Third intolerable burden: _____

Part 3

If you need a repeated small bowel examination, which test would you like to choose, CTE or DBE?

- ☐ CTE
- ☐ DBE

Figure S2 Questionnaire B.

Abbreviations: CTE, computed tomography enterography; DBE, double-balloon enteroscopy.

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