Indications, detectability, positive findings, total enteroscopy, and complications of diagnostic double-balloon endoscopy: a systematic review of data over the first decade of use

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Background: Double-balloon endoscopy (DBE) has been used in clinical practice for nearly 10 years.

Objective: To systematically collect and produce pooled data on indications, detection rate, total enteroscopy, complications, and the composition of positive findings in diagnostic DBE.

Design: A systematic review.

Main Outcome Measurements: We searched PubMed between January 1, 2001 and March 31, 2010 for original articles about DBE evaluation of small-bowel diseases. Data on total number of procedures, distribution of indications, pooled detection rate, pooled total enteroscopy rate, and composition of positive findings were extracted and/or calculated. In addition, the data involving DBE-associated complications were analyzed.

Results: A total of 66 English-language original articles involving 12,823 procedures were included. Suspected mid-GI bleeding (MGIB) was the most common indication (62.5%), followed by symptoms/signs only (7.9%), small-bowel obstruction (5.8%), and Crohn's disease (5.8%). The pooled detection rates were 68.1%, 68.0%, 53.6%, 63.4%, and 85.8% for overall, suspected MGIB, symptoms/signs only, Crohn's disease, and small-bowel obstruction, respectively. Inflammatory lesions (37.6%) and vascular lesions (65.9%) were the most common findings, respectively, in suspected MGIB patients of Eastern and Western countries. The pooled total enteroscopy rate was 44.0% by combined or antegrade-only approach. The pooled minor and major complication rates were 9.1% and 0.72%, respectively.

Limitations: Inclusion and exclusion criteria were loosely defined.

Conclusion: The detectability and complication risk of diagnostic DBE are acceptable. Suspected MGIB is the most common indication, with a relatively high detection rate, but there was a difference in its causes between Western and Eastern countries. (Gastrointest Endosc 2011;74:563-70.)

Endoscopy has become enormously popular throughout the world because of its proven values in the diagnosis and treatment of digestive diseases.[1] Since the first article introducing double-balloon endoscopy (DBE) was published in *Gastrointestinal Endoscopy* in 2001,[2] DBE has been widely used in clinical practice worldwide. DBE can be used to explore a large part of the small bowel in either antegrade or retrograde approach and has advantages including handing control, biopsy, and endoscopic treatment. Therefore, DBE has been performed in many medical centers for the diagnosis of patients with small-bowel signs and symptoms or for the treatment of patients with a

Abbreviations: DBE, double-balloon endoscopy; MGIB, mid-GI bleeding.

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clear diagnosis. Because of its relatively high detectability of small-bowel lesions, the composition of positive findings of DBE can reflect the small-bowel disease pattern to some extent, especially in terms of obscure GI bleeding.[3] Although DBE is widely recognized as a useful diagnostic modality, there still exists the possibility of missing potential lesions or inaccessibility to the entire small bowel, and major complications such as pancreatitis and perforation have been reported.[4-6]

Up to now, there have been many published original articles across the world addressing the technical aspects and positive findings of DBE; however, most of these studies were of small sample size and show inconsistent, if not controversial, data among different settings and in different countries.[7-10] Moreover, over the past decade, there was no systematic review of the overall performance of diagnostic DBE nor was there a comprehensive appraisal of the pros and cons of diagnostic DBE. Therefore, we performed this systematic review of all eligible studies related to diagnostic DBE during the decade of development in order to produce state-of-the-art data on indications, detectability, total enteroscopy, and complications in examining small-bowel diseases. Moreover, positive findings of DBE, especially in patients with small-bowel bleeding, were collected and analyzed to reflect the spectrum of small-bowel disease in different regions.

Take-home Message

- Double-balloon endoscopy (DBE) is a valuable modality, with a pooled detection rate of 68.1% for all small-bowel disease. Inflammatory lesions and vascular lesions are the most common findings in patients with suspected mid-GI bleeding in Eastern and Western countries, respectively, according to DBE.

METHODS

Strategy, criteria, and procedures for the literature search

The literature search was conducted in PubMed on April 1, 2010, and all publications related to DBE between January 1, 2001 and March 31, 2010 were retrieved. The search terms were "double-balloon endoscopy OR double-balloon enteroscopy OR double-balloon endoscope OR push-and-pull enteroscopy OR small-bowel endoscopy," which were mainly based on the Medical Subject Headings (MeSH) of Pubmed. Additionally, the search was limited to "humans" and "English."

Inclusion and exclusion criteria were delineated before commencement of the literature search. All initial search results were reviewed by titles and abstracts. The potential original articles mainly focusing on diagnosing small-bowel diseases were identified, and full texts were obtained and reviewed for further manual data retrieving. Studies in which DBE was performed for the evaluation of gastric or colonic diseases or for a therapeutic purpose only were excluded. Studies in which DBE was used with other diagnostic tools for small-bowel diseases were included, but only DBE data were collected. Studies that reported both diagnostic and therapeutic DBEs were included, but only data on the diagnostic aspect such as indications, detectability, positive findings, and complications were retrieved. In the case of multiple publications of the same dataset, we selected only the version with most cases or the most relevant version. All articles other than original contributions, such as case reports, reviews, guideline/consensus articles, meta-analyses, comments, editorials, letters, and news were excluded from further extraction of the data defined hereafter. The detailed search procedures are outlined in Figure 1.

Definitions

In order to include all relevant articles without loss of the fundamental meanings of the terms, major parameters such as indications, positive findings, complications, and other parameters assessed in the present study were defined in a relatively broad way, so that data on these parameters from different studies could be identified, collected, and categorized.

Indications were defined as the primary reasons for DBE. According to the reclassification of GI bleeding,[11] the term *suspected mid-gastrointestinal bleeding* was adopted and defined as overt or occult bleeding from the GI tract that persists or recurs without positive findings after upper and/or lower GI endoscopy and in which small-bowel bleeding was suspected. Crohn's disease was defined as definite or suspected Crohn's disease on the basis of the clinical course or colonoscopy findings.[12] Celiac disease included definite disease according to duodenal histology or suspected disease based on weight loss, anemia, diarrhea, and other symptoms relating to a gluten-containing diet.[13] Indication of neoplastic lesions referred to the situation in which patients were screened for small-bowel tumors or polyposis because of alarming signs and symptoms or relevant family history (eg, familial polyposis).[14] Small-bowel obstruction was defined as the presence of abdominal pain, vomiting, or other symptoms and related imaging supporting complete or partial blockage of the small bowel.[15] Any clinical symptoms such as abdominal pain, diarrhea, weight loss, and other major GI complaints not included in any of the previous categories were categorized as indications of *symptoms/signs only*. *Abnormalities in other modalities* were defined as suspected GI lesions found in other examinations (capsule endoscopy, colonoscopy, CT, etc) that required DBE for further confirmation. Indications not stated earlier were categorized as *others*.

In this review, DBE findings that could explain the symptoms of the patient and resulted in a change in

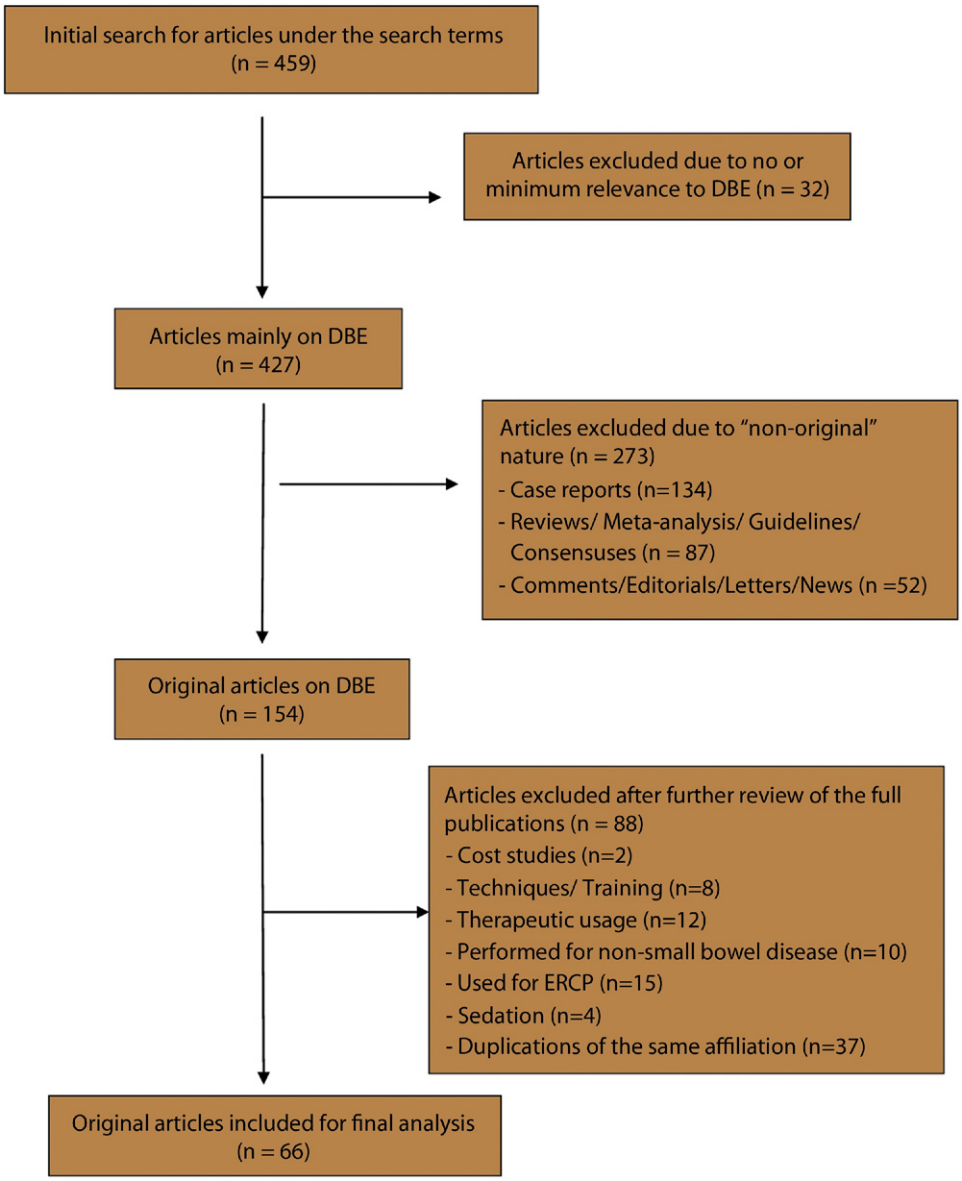

Figure 1. Flow chart for literature search on original articles relevant to diagnostic double-balloon endoscopy. *DBE,* double-balloon endoscopy.

therapeutic management were considered positive findings, which included any clinically significant findings in the entire GI tract. Because a number of patients underwent two or more DBE procedures, the detection rate was calculated as the ratio of cases with positive findings over all cases; this approach has been applied in most previous relevant studies.[10,12,15-17] The positive findings for composition analysis were hereby limited to small bowel and were further classified into 5 broad categories based on most of the articles, that is, vascular lesions (including angiectasia, arteriovenous malformation, varix, active bleeding, etc), inflammatory lesions (including Crohn's disease, erythema, erosions, ulcers, etc), neoplastic lesions (benign or malignant), diverticula, and others (any positive findings not included in the previous categories).

Total enteroscopy was defined when the entire small bowel was successfully visualized, either through antegrade (oral) or combined (oral and anal) approaches according to a tattoo mark. Accordingly, the total enteroscopy rate was defined as the ratio of cases with the enteroscopy successfully passing through the entire small intestine over the total cases, with attempts to examine the entire small intestine before or after the first approach.

Complications of DBE were defined as any adverse events that occurred during and after the procedures and were divided into minor and major categories. The former included GI symptoms such as nausea, vomiting, abdominal distension, and other transient and self-limiting symptoms. The latter included any severe adverse events that required hospitalization and/or an

endoscopic or surgical intervention and/or contributed to the death of the patient. Complication rate was defined by the ratio of the number of procedures with complications over total procedures.

Data extraction from eligible articles

The total numbers of patients and DBE procedures were collected, followed by collection of the indication data whenever the data were consistent with the earlier definitions, or the original data could be categorized based on the definitions. The results of positive findings, total enteroscopy rate, and complication rate were generated from articles with adequate information. Then, available data about detection rate for each of the defined indications and positive findings of suspected mid-GI bleeding were separately extracted for further analyses. Missing data or indeterminate definitions were resolved by direct contact with authors if possible. Two authors (L.X., Z.L.) identified the relevant original articles and extracted the data independently, whereas the third author (Z.-S.L.) checked the results. If a disagreement existed, the relevant procedures were repeated until a consensus was achieved among the authors.

Statistical analysis

Meta-analysis for the pooled results of the detection rate, total enteroscopy rate, and complication rate were performed. Statistical heterogeneity was measured by using Cochran's Q test; a P value $< .05$ was considered significant for heterogeneity. A fixed or random effects model was applied when there was nonsignificant or significant heterogeneity. Moreover, the 95% confidence interval (CI) also was calculated. All analyses were performed with StatDirect Statistical software, version 2.7.8 (StatsDirect Ltd, Altrincham, UK).

RESULTS

Bibliometrics

A total of 459 articles of any publication type were identified at the initial search. When the titles or abstracts were screened, 32 articles were found to have no or minimum relevance to DBE and thus were excluded from further review. Of the remaining 427 articles mainly relevant to DBE, 154 were categorized as original articles (Fig. 1).

The total number of DBE-related original articles increased steadily between 2001 and 2004, sharply after 2004, reached a peak in 2007, and then decreased in 2008 and 2009 (Fig. 2). Of the 154 original articles, 88 did not specifically address the performance of diagnostic DBE in small-bowel disease. Therefore, a total of 66 original articles (31 prospective studies, 35 retrospective studies) regarding DBE, involving 8957 patients (12,823 procedures), were finally included in the analysis (Fig. 1). According to the authors' institutions, 33 (50.0%) articles were from Asia, 22 (33.3%) were from Europe, 7 (10.6%) were from North America, and 4 (6.1%) were from other regions. Full texts of all 66 articles were successfully obtained from online access, the authors, or libraries, and the required data were collected and/or calculated.

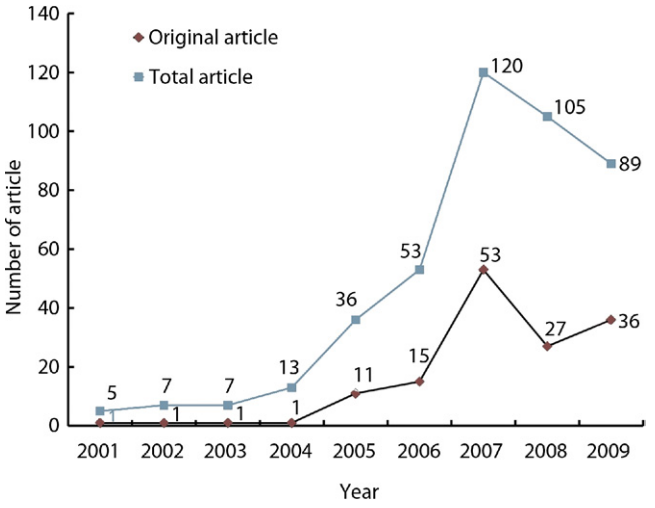

Figure 2. Trends of total number of articles (n = 435) and original articles (n = 146) on double-balloon endoscopy from 2001 to 2009.

TABLE 1. Indications for double-balloon endoscopy in the final included original articles

Indication	No. of patients (procedures)	% of patients (procedures, %)
Suspected mid-GI bleeding	5268 (7384)	62.5 (60.2)
Symptoms/signs only	662 (820)	7.9 (6.7)
Small-bowel obstruction	490 (848)	5.8 (6.9)
Crohn's disease	486 (748)	5.8 (6.1)
Abnormality in other modalities	404 (741)	4.8 (6.0)
Neoplastic lesion	384 (572)	4.6 (4.7)
Celiac disease	44 (51)	0.5 (0.4)
Other	686 (1103)	8.1 (9.0)
Total	8424 (12,267)	100.0 (100)

Indications

Indications consistent with the earlier-mentioned definitions were described in 58 studies with 8424 patients and 12,267 procedures in total. Suspected mid-GI bleeding was the most common indication, accounting for 5268 (62.5%) patients, followed by symptoms/signs only (7.9%), small-bowel obstruction (5.8%), Crohn's disease (5.8%), abnormality in other modalities (4.8%), neoplastic lesions (4.6%), and celiac disease (0.5%). Moreover, 686 (8.1%) patients were categorized to other indications (Table 1).

TABLE 2. Pooled detection rate according to indications

Indication	No. of articles (total cases)	Pooled detection rate, %	95% CI, %
Suspected mid-GI bleeding	31 (2889)	68.0	62.9-72.8
Symptoms/signs only	8 (481)	53.6	44.6-62.5
Crohn's disease	8 (180)	63.4	42.0-82.3
Small-bowel obstruction	4 (114)	85.8	67.5-97.3
Total	45 (5615)	68.1	64.3-71.7

CI, Confidence interval.

TABLE 3. Pooled detection rate according to region

Region	No. of articles (total patients)	Pooled detection rate, %	95% CI, %
Asia	23 (3337)	70.5	65.5-75.3
Europe	16 (1602)	66.7	60.6-72.6
North America	4 (576)	60.8	42.8-77.5
Other	2 (100)	65.5	45.4-83.1
Total	45 (5615)	68.1	64.3-71.7

CI, Confidence interval.

Detection rates and composition of positive findings

Detection rates according to patients were reported in 45 studies involving 5615 patients. The total pooled detection rate was 68.1% (95% CI, 64.3%-71.7%). Detection rates specifically reported for the indications were: suspected mid-GI bleeding, 31 studies; symptoms/signs only, 8 studies; Crohn's disease, 8 studies; and small-bowel obstruction, 4 studies, with the rates being 68.0%, 53.6%, 63.4%, and 85.8%, respectively (Table 2). When these 45 articles were analyzed according to regional distribution, the total pooled detection rates were 70.5%, 66.7%, 60.8%, and 65.5%, respectively, in Asia, Europe, North America, and other regions (Table 3).

Detailed positive DBE findings were described in 41 articles. Among the 4657 patients, 3417 positive findings were detected. Among these positive findings, inflammatory lesions were the most common diagnoses, with a proportion of 32.7% (n = 1116), followed by vascular lesions (29.3%, n = 1001), neoplastic lesions (22.8%, n = 780), other lesions (11.3%, n = 387), and diverticula (3.9%, n = 133) (Table 4). When this analysis was limited to the suspected mid-GI bleeding indication, with 1648 positive findings, the sequence was vascular lesions (40.4%), inflammatory lesions (29.9%), neoplastic lesions (22.2%), diverticula (4.9%), and other lesions (2.7%) (Table 4). The compositions in Europe, America, and Australia were similar, where vascular lesions accounted for 62.2%, 63.0%, and 70.5%, respectively. However, the distribution in the positive findings was different between Eastern countries (China, Japan, Korea, etc) and Western countries/continents (Europe, North America, and Australia), with inflammatory lesions (37.6%) and vascular lesions (65.9%) being the most common findings, respectively, in the two regions (Fig. 3).

TABLE 4. Composition of positive findings in patients with all indications and only suspected mid-GI bleeding

Category of finding	All indications, no. (%)	Suspected mid-GI bleeding, no. (%)
Inflammatory lesion	1116 (32.7)	493 (29.9)
Vascular lesion	1001 (29.3)	665 (40.4)
Neoplastic lesion	780 (22.8)	366 (22.2)
Diverticulum	133 (3.9)	80 (4.9)
Other lesion	387 (11.3)	44 (2.7)
Total positive findings	3417 (100.0)	1648 (100.0)

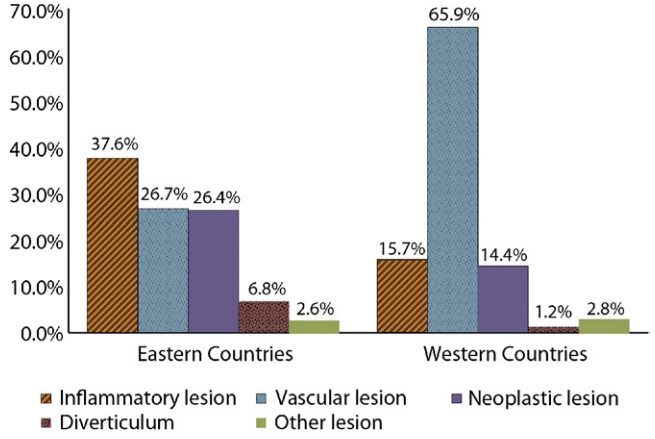

Figure 3. Composition of positive findings in patients with obscure GI bleeding according to regional distribution.

Total enteroscopy rate

Data on total enteroscopy were reported in 23 studies involving 1143 patients, with successful total enteroscopy being achieved in 569 patients. Thus, the pooled total enteroscopy rate was 44.0% (95% CI, 35.0%-53.3%). In the patients with successful total enteroscopy, only 1.6% (9/

569) was completed by the antegrade approach, and others were by a combined approach.

Complication rate

Overall, data on minor complications were described in 15 articles involving 2017 procedures, and a total of 202 minor complications were reported, with a pooled minor complication rate of 9.1% (95% CI, 5.2%-14.0%). Moreover, major complications were reported in 40 articles involving 9047 procedures. A total of 61 major complications were reported, with a pooled major complication rate of 0.72% (95% CI, 0.56%-0.90%). The major complications included perforation (n = 20), pancreatitis (n = 17), bleeding (n = 6), aspiration pneumonia (n = 8), and others (n = 10). In the 20 patients with perforation, 5 had inflammatory bowel disease (3 of whom underwent related surgery), 4 had a history of surgery, and 3 had tumors where the perforation was located. In the 6370 antegrade DBE procedures, the pooled pancreatitis rate was 0.49% (95% CI, 0.33%-0.67%). During the 40 studies, only one procedure-related death was reported (0.01%). An 83-year-old man with underlying chronic obstructive pulmonary disease and ischemic heart disease died of acute myocardial infarction during an antegrade DBE procedure with the indication of recurrent overt bleeding.[18]

DISCUSSION

The diagnostics of small-bowel diseases have evolved dramatically since the advent of both capsule endoscopy and DBE over the past decade. A large number of studies on diagnostic DBE have been reported for its significant advantages in evaluating small-bowel diseases, especially when compared with push endoscopy and other conventional diagnostic tools.[19-21] Our study determined that the pooled detection rate of DBE was 68.1% for all patients. There are several possible explanations for the inability to identify lesions in about one-third of patients. First, a considerable portion of DBE procedures fail to achieve total enteroscopy, as shown in the present study. Second, the lesions may be missed by previous endoscopic examinations before DBE. Fry et al[22] reported that a definite source of bleeding outside the small bowel was detected in 24.3% of patients and suggested that repeat EGD and ileocolonoscopy should be taken into consideration before DBE. Third, in a proportion of cases, the lesions, especially in cases of mild bleeding, may have healed spontaneously and can hardly be differentiated from the normal mucosa during DBE examination. Although DBE failed to identify a proportion of lesions, we consider that the performance is acceptable because the symptoms of a significant proportion of patients without positive findings would not recur during follow-up.[3,15,23,24] In other words, a "negative" DBE finding may also provide a "positive" impact in clinical practice.

In the present study, suspected mid-GI bleeding was the most common indication, which covered 62.5% of cases. Detection rates of DBE for suspected mid-GI bleeding in the large sample size studies were between 49.2% and 80.6%.[3,15,17,23] The potential explanation for this relatively high heterogeneity would be that there were different ratios of overt and occult small-bowel bleeding among the studies. Tanaka et al[25] reported that DBE detection rates for patients with overt-ongoing, overt-previous, and occult bleeding were 100.0%, 48.4%, and 42.1%, respectively, and the difference was statistically significant ($P < .005$). In the present study, vascular lesions, inflammatory lesions, and neoplastic lesions rank as the top 3 positive findings among patients with suspected mid-GI bleeding. These observations were consistent with results of our previous study evaluating the performance of capsule endoscopy in diagnosing small-bowel diseases.[26] In addition, our further analysis confirmed an intriguing observation by Tanaka et al[25] that there existed a difference of composition of obscure GI bleeding, namely, suspected mid-GI bleeding lesions, between Eastern and Western countries. In Eastern countries, inflammatory lesions were the most common diagnoses (37.6%), followed by vascular lesions (26.7%) and neoplastic lesions (26.4%), whereas in Western countries, vascular lesions accounted for nearly two-thirds (65.9%) of positive findings, followed by inflammatory lesions (15.7%) and neoplastic lesions (14.4%). Our recent analysis on positive capsule endoscopy findings of 1232 Chinese patients with obscure GI bleeding also showed that tumors and polyps made up nearly 30% of lesions.[27] Therefore, special attention should be paid to small-bowel tumors for patients with suspected mid-GI bleeding in Eastern countries, although there has been no valid explanation for the variation in pathologies between patients with mid-GI bleeding among different regions.

The total enteroscopy rate and complication rate of DBE have caused much concern in both physicians and patients, because in most cases the lesions were detected during the first attempt, and thus there was no need for an additional opposite approach to visualize the entire small bowel. Therefore, the total enteroscopy rate analysis in the present review was performed strictly in patients in whom an attempt to examine the entire small intestine was made, and the total enteroscopy rate in all 12,823 DBEs cannot be estimated. In 1143 such cases, the pooled total enteroscopy rate was 44.0%, leaving the possibility of missing lesions. With this relatively low rate, no studies so far have tried to determine specifically the factors that contributed to the incomplete examination of total enteroscopy and the corresponding solutions, which is an area that requires further investigation.

DBE is considered to be a safe procedure with few complications, most of which are minor. The present study showed a minor complications rate of 9.1%. Similar to any endoscopic procedures, minor complications encountered include throat discomfort, abdominal distension, or fever. Moreover, major complications may occur in some cases.

The present study showed a major complication rate of 0.72%, which is lower than the largest-ever study from the German DBE register,[28] which included 3894 diagnostic and interventional DBEs with 48 (1.2%) major complications. However, in the German study, pancreatitis occurred in 0.34% of cases after antegrade DBE, and major bleeding and perforation occurred mainly during interventional procedures. The inclusion of interventional procedures may explain the major difference between the two studies. In addition, 8 cases with aspiration pneumonia were collected in this review, and all of them were reported during antegrade DBE,[12,25,29,30] which indicates that antegrade DBE requiring sedation should always be conducted with close monitoring both during and after the procedure to prevent aspiration pneumonia or respiratory compromise. Based on the present study, perforation and pancreatitis are the most frequent major complications for diagnostic DBE and should be taken into consideration in written informed consent.

Capsule endoscopy and DBE were compared in some studies in terms of diagnostic yield or detection rates in order to determine the most feasible and effective tool for the diagnosis of small-bowel diseases.[6,12,16,17,23] As shown in a meta-analysis including 11 studies, capsule endoscopy and DBE have comparable diagnostic yields in small-bowel disease (capsule endoscopy, 60%; DBE, 57%; $P = .42$).[31] However, detection rate is not the only performance criterion for physicians to select a diagnostic tool, and safety plus the ability to examine the entire small bowel are also important issues. As shown in our previous review,[24] the pooled completion rate of capsule endoscopy was 83.5% for overall cases, and the main complication was capsule retention, with a relatively high retention rate in patients with Crohn's disease (2.6%) and neoplasms (2.1%). The present review showed that the pooled total enteroscopy rate of DBE was 44.0%. This rate, after that achieved by capsule endoscopy, was the second highest among those achieved by all modalities for small-bowel disease. However, the total enteroscopy rate of DBE is associated with a possibility of major complications, including death. Therefore, how to select the DBE approach or combine DBE with other modalities for different indications demands further clinical trials and cost-effectiveness analysis.

There are several limitations to our study. First, we defined the major parameters broadly in order to include all relevant articles; however, the fundamental meanings of the terms were not changed. Second, the relationship between the complications and sedation or aspiration during diagnostic advancement or during withdrawal and therapy could not be defined, because the original articles did not specifically report the data. Thus, the possibility that some complications, such as aspiration pneumonia, may be related to sedation or aspiration cannot be ruled out.

In conclusion, the detection rate and complication rate of DBE are acceptable. Suspected mid-GI bleeding is the most common indication for DBE, with a relatively high detection rate. Inflammatory lesions and vascular lesions are the most common findings in patients with suspected mid-GI bleeding in Eastern and Western countries, respectively, according to DBE.

REFERENCES

1. Cotton PB. Quality endoscopists and quality endoscopy units. J Interv Gastroenterol Epub 2011 Mar 1.
2. Yamamoto H, Sekine Y, Sato Y, et al. Total enteroscopy with a nonsurgical steerable double-balloon method. Gastrointest Endosc 2001 Mar 1;53:216-20.
3. Ohmiya N, Yano T, Yamamoto H, et al. Diagnosis and treatment of obscure GI bleeding at double balloon endoscopy. Gastrointest Endosc 2007;66:S72-7.
4. Gerson LB, Tokar J, Chiorean M, et al. Complications associated with double balloon enteroscopy at nine US centers. Clin Gastroenterol Hepatol 2009;7:1177-82.
5. Kopacova M, Rejchrt S, Tacheci I, et al. Hyperamylasemia of uncertain significance associated with oral double-balloon enteroscopy. Gastrointest Endosc 2007;66:1133-8.
6. Nakamura M, Niwa Y, Ohmiya N, et al. Preliminary comparison of capsule endoscopy and double-balloon enteroscopy in patients with suspected small-bowel bleeding. Endoscopy 2006;38:59-66.
7. Zhi FC, Yue H, Jiang B, et al. Diagnostic value of double balloon enteroscopy for small-intestinal disease: experience from China. Gastrointest Endosc 2007;66:S19-21.
8. Cazzato IA, Cammarota G, Nista EC, et al. Diagnostic and therapeutic impact of double-balloon enteroscopy (DBE) in a series of 100 patients with suspected small bowel diseases. Dig Liver Dis 2007;39:483-7.
9. Yamamoto H, Kita H, Sunada K, et al. Clinical outcomes of double-balloon endoscopy for the diagnosis and treatment of small-intestinal diseases. Clin Gastroenterol Hepatol 2004;2:1010-6.
10. Gross SA, Stark ME. Initial experience with double-balloon enteroscopy at a U.S. center. Gastrointest Endosc 2008;67:890-7.
11. Ell C, May A. Mid-gastrointestinal bleeding: capsule endoscopy and push-and-pull enteroscopy give rise to a new medical term. Endoscopy 2006;38:73-5.
12. Fukumoto A, Tanaka S, Shishido T, et al. Comparison of detectability of small-bowel lesions between capsule endoscopy and double-balloon endoscopy for patients with suspected small-bowel disease. Gastrointest Endosc 2009;69:857-65.
13. Hadithi M, Al-toma A, Oudejans J, et al. The value of double-balloon enteroscopy in patients with refractory celiac disease. Am J Gastroenterol 2007;102:987-96.
14. Waterman M, Eliakim R. Capsule enteroscopy of the small intestine. Abdom Imaging 2009;34:452-8.
15. Zhong J, Ma T, Zhang C, et al. A retrospective study of the application on double-balloon enteroscopy in 378 patients with suspected small-bowel diseases. Endoscopy 2007;39:208-15.
16. Arakawa D, Ohmiya N, Nakamura M, et al. Outcome after enteroscopy for patients with obscure GI bleeding: diagnostic comparison between double-balloon endoscopy and videocapsule endoscopy. Gastrointest Endosc 2009;69:866-74.
17. Marmo R, Rotondano G, Casetti T, et al. Degree of concordance between double-balloon enteroscopy and capsule endoscopy in obscure gastrointestinal bleeding: a multicenter study. Endoscopy 2009;41:587-92.
18. Lin WP, Chiu CT, Su MY, et al. Treatment decision for potential bleeders in obscure gastrointestinal bleeding during double-balloon enteroscopy. Dig Dis Sci 2009;54:2192-7.
19. May A, Nachbar L, Schneider M, et al. Prospective comparison of push enteroscopy and push-and-pull enteroscopy in patients with suspected small-bowel bleeding. Am J Gastroenterol 2006;101:2016-24.
20. Ohmiya N, Arakawa D, Nakamura M, et al. Small-bowel obstruction: diagnostic comparison between double-balloon endoscopy and fluoroscopic enteroclysis, and the outcome of enteroscopic treatment. Gastrointest Endosc 2009;69:84-93.
21. Matsumoto T, Moriyama T, Esaki M, et al. Performance of antegrade double-balloon enteroscopy: comparison with push enteroscopy. Gastrointest Endosc 2005;62:392-8.

22. Fry LC, Bellutti M, Neumann H, et al. Incidence of bleeding lesions within reach of conventional upper and lower endoscopes in patients undergoing double-balloon enteroscopy for obscure gastrointestinal bleeding. Aliment Pharmacol Ther 2009;29:342-9.
23. Ross A, Mehdizadeh S, Tokar J, et al. Double balloon enteroscopy detects small bowel mass lesions missed by capsule endoscopy. Dig Dis Sci 2008;53:2140-3.
24. Gerson LB, Batenic MA, Newsom SL, et al. Long-term outcomes after double-balloon enteroscopy for obscure gastrointestinal bleeding. Clin Gastroenterol Hepatol 2009;7:664-9.
25. Tanaka S, Mitsui K, Yamada Y, et al. Diagnostic yield of double-balloon endoscopy in patients with obscure GI bleeding. Gastrointest Endosc 2008;68:683-91.
26. Liao Z, Gao R, Xu C, et al. Indications and detection, completion, and retention rates of small-bowel capsule endoscopy: a systematic review. Gastrointest Endosc 2010;71:280-6.
27. Liao Z, Gao R, Li F, et al. Fields of applications, diagnostic yields and findings of OMOM capsule endoscopy in 2400 Chinese patients. World J Gastroenterol 2010;16:2669-76.
28. Moschler O, May AD, Muller MK, et al. Complications in double-balloon-enteroscopy: results of the German DBE register [in German with an English abstract]. Z Gastroenterol 2008;46:266-70.
29. Kodama M, Uto H, Numata M, et al. Endoscopic characterization of the small bowel in patients with portal hypertension evaluated by double balloon endoscopy. J Gastroenterol 2008;43:589-96.
30. Araki A, Tsuchiya K, Okada E, et al. Single-operator double-balloon endoscopy (DBE) is as effective as dual-operator DBE. J Gastroenterol Hepatol 2009;24:770-5.
31. Pasha SF, Leighton JA, Das A, et al. Double-balloon enteroscopy and capsule endoscopy have comparable diagnostic yield in small-bowel disease: a meta-analysis. Clin Gastroenterol Hepatol 2008;6:671-6.