RESEARCH ARTICLE

Double Balloon Enteroscopy: The Growing Indications and Experience

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Abbreviations

APC: Argon Plasma Coagulation
CE: Capsule Endoscopy
CT: Computerised Tomography
DBE: Double Balloon Enteroscopy
DAE: Device Assisted Enteroscopy
EATL: Enteropathy-associated T-cell lymphoma
EBD: Endoscopic Balloon Dilation
ERCP: Endoscopic retrograde cholangiopancreatography
EUS: Endoscopic ultrasound
GI: Gastrointestinal
MRE: Magnetic Resonance Enterography
SBE: Single Balloon Enteroscopy
PTC: Percutaneous Transhepatic Cholangiogram

Summary

Double-balloon enteroscopy (DBE) has revolutionised the investigation and diagnosis of small bowel diseases. This technique means that every part of the digestive system is now potentially accessible. This review will discuss the technique, its indications and its future uses.

Introduction

The small bowel is over four times the length of the large bowel and has greater tendency to form loops. It was traditionally considered inaccessible. This has changed with the introduction of double-balloon enteroscopy (DBE) – it has revolutionised the diagnosis and management of small bowel diseases. The technique, first described by Yamamoto in 2001(1), was the first modality to achieve panenteroscopy: complete visualisation and access to the small intestine for diagnostic and therapeutic purposes. DBE allows targeted mucosal biopsy, snare polypectomy, injection therapy, tattooing, balloon dilation of strictures, argon plasma coagulation (APC), placement of hemostatic clips, retrieval of capsules and foreign bodies, and enteroscopy-assisted ERCP in surgically altered anatomy. Its predecessor, push enteroscopy, provided all the advantages of conventional endoscopy but only a limited depth of small bowel visualisation could be achieved (about 120cm beyond the ligament of Treitz) (2). Capsule endoscopy (CE) available since 2001 allowed mucosal visualization of the entire small bowel in a minimally invasive manner for the first time but was limited by its inability to perform therapeutic intervention. In this review we will outline the expanding role of DBE in Gastroenterology.

Technique and Equipment

DBE was first commercially available in 2003. DBE is manufactured by Fujinon (Tokyo, Japan) and single balloon enteroscopy (SBE) by Olympus (Tokyo, Japan). There are different types of DBE depending on the total length of the enteroscope, outer diameter, inner working channel diameter, and field of view. EN-450T5 and EN-450P5 are the most commonly used DB enteroscopes. The P-type (EN-450P5, Fujinon) is the thinnest (measuring 8.5mm) allowing panenteroscopy, with a channel diameter of only 2.2mm. The T-type (EN-450T5, Fujinon) measures 9.4mm with a channel of 2.8 or 3.2mm. There is also a shorter enteroscope (EC450-B15, Fujinon) measuring 152cm long used specifically for balloon assisted ERCP(2).

Latex balloons measuring 35-mm in diameter are attached to the distal ends of both the flexible high resolution endoscope and the polyurethane overtube for stabilization of the bowel. Air from an external pressure-controlled pump system inflates and deflates the balloons with a maximum pressure that does not exceed 6 kPa (Figure 1).

Figure 1: Double- balloon enteroscope (Push and pull enteroscope)

The technique can be done in an anterograde (oral route) or retrograde (anal route) fashion and commonly requires two people. The decision regarding route selection is based on prior imaging and estimation of whether the lesion in question is in the proximal two thirds or distal third of the small bowel(2). Standard colonoscopy bowel preparation is essential for retrograde DBE and is preferable for anterograde DBE. Most providers choose general anaesthesia with the patient intubated for anterograde DBE and at least monitored anaesthesia care for retrograde DBE. The 'push-pull technique' is as follows: the balloon at the overtube tip is inflated beyond the ampulla to maintain a stable position and the enteroscope is advanced through the overtube, deep into the small bowel. The balloon on the overtube is then deflated and the balloon on the endoscope is inflated. The overtube is then inserted over the endoscope until the tip of the endoscope is reached. The inflated balloon attached to the tip of the endoscope prevents the endoscope tip from slipping back as the overtube is advanced. Following this, both the enteroscope and the overtube are pulled back with inflated balloons and the small bowel accordioned over the scope (Figure 2). Advancement into the duodenum or terminal ileum is achieved using standard endoscopic principles. For ileal intubation, it is essential to ensure that there is sufficient flexible enteroscope beyond the overtube balloon to make it floppy enough to be manoeuvred across the Ileocecal valve. Once the balloon is inflated in the cecum, the DBE-Overtube is pulled back to decrease the ileo-colonic angle to facilitate ileal intubation(2). This is followed by advancement of the enteroscope into the ileum and inflation of the balloon attached to the enteroscope to stabilize it. Then the overtube-balloon is deflated and inserted into the ileum over the enteroscope.

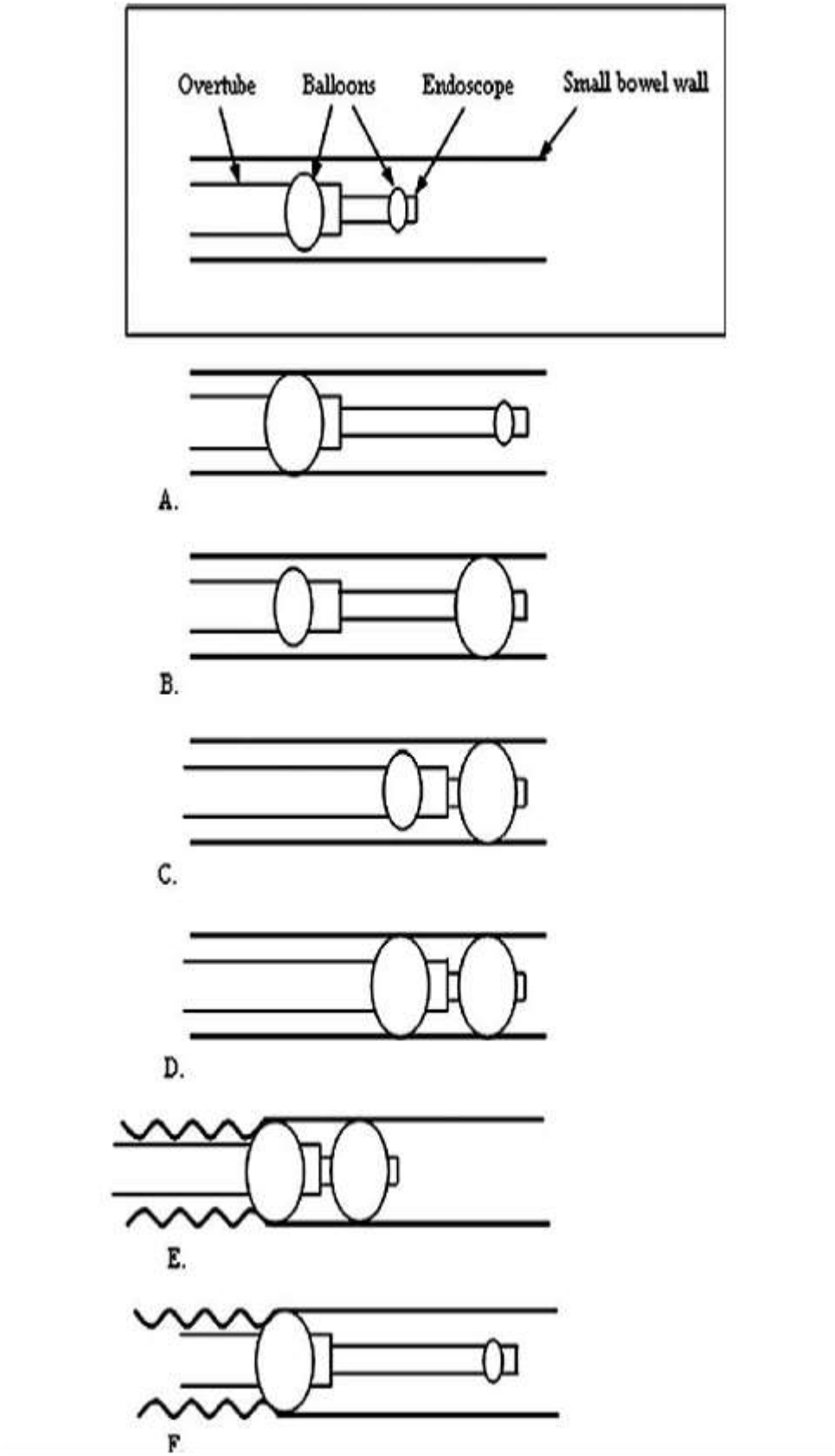

Figure 2. Schematic representation of mechanism of action of double balloon enteroscopy

Change of position and abdominal pressure helps(2). Simultaneous withdrawal of the inflated overtube and advancement of the scope might be useful in recalcitrant looping and to advance through adhesions(3). Fluoroscopic guidance is useful during the early part of the learning curve, to visualise scope advancement and effective loop reduction. It is also useful in patients with adhesions where one anticipates more looping and difficult enteroscopy. Fluoroscopy demonstrates that during insertion, clockwise rotation of the enteroscope forms an intra-gastric loop to recur, hindering effective advancement. For anterograde and retrograde DBE, 10 and 30 cases respectively are recommended under supervision for training(4)(5).

The small bowel does not have any reproducibly distinctive features to assist in estimation of the depth of insertion(6)(7). Therefore, India Ink is used to tattoo the distal most point reached via one route. When this tattoo is then reached using the other route then pan-enteroscopy has been achieved. In up to 86% of cases the entire small bowel can be vizualised using a combination of both approaches (3). However, in the majority of cases a total enteroscopic examination is not required as balloon enteroscopy is usually performed in a 'targeted' manner to identify and treat small bowel pathology identified on prior imaging. In instances where pan-enteroscopy is required, it is preferable to perform DBE via the oral and anal routes on different days(4).

The most common adverse event reported was hypoxia when moderate sedation was used (5). Use of carbon dioxide insufflation along with under-water enteroscopy helps to minimise complications and discomfort. Technical failure may occur due to excess looping, which prevents the endoscope reaching its target despite use of the balloons, removable stiffening wire (via the working channel) and abdominal pressure. The use of fluoroscopy in combination with endoscopic views helps in calculated reduction of loops and can be helpful. The balloon on the enteroscope can be used only once, whereas the overtube-balloon system can be reused.

A study across 6 tertiary care centers in the US described the performance parameters for DBE. Mehdizadeh *et al*. reported mean procedure duration of 110 minutes for the first 10 cases and 92 minutes for subsequent cases (6). However, the duration of retrograde DBE and the mean depth of insertion remained unchanged, although there was a significant reduction in mean fluoroscopy time. Diagnostic or therapeutic interventions were performed in 64% of cases, leading to a diagnosis in 43% of cases. Ileal intubation could not be achieved in 31% of retrograde DBE because of technical difficulties.

To help improve ileal intubation, the impact of a preliminary standard colonoscopy has been studied. One study of 45 patients showed superior results when a preliminary colonoscopy with a paediatric colonoscope was performed. Retrograde DBE ileocecal valve intubation rates with and without colonoscopy were 100% and 73%, respectively ($p<0.003$) (7). This benefit was thought to be from the initial intubation of the ileocecal valve by the colonoscope, which dilated and oriented the valve for later access with retrograde DBE. Other potential factors were easy cleansing of the colon with the colonoscope and straightening of the colon by colonoscope which would facilitate easy passage of DBE immediately following this.

The Role of DBE in the management of small bowel disorders

The three major indications for DBE are: assessment of small-bowel CD; obscure mid

gut GI bleeding, and evaluation of small bowel masses (as in Peutz-Jeghers syndrome). DBE can be used in all patients including those with ileus and obstruction (8). The advantages of DBE compared with CE are the avoidance of the risk of capsule retention, the capabilities for biopsy, and therapeutic interventions. The experience across four European medical centers demonstrated that DBE was beneficial in reducing hospitalization and avoiding repeated diagnostic workup, including intraoperative enteroscopy and surgical interventions in patients with suspected or previously documented small-bowel disease (9).

Crohn's disease

The role of DBE in small bowel CD has grown over the last decade, both for diagnosis and treatment. Crohn's disease can cause ulcers, strictures, inflammation, fistula, abscess, perforation, adenocarcinoma and obscure bleeding (10).

Suspected Crohn's disease

DBE aids in the assessment of the extent and severity of small bowel CD, especially when imaging such as MRE and CE is inconclusive, but there is a strong clinical suspicion of CD. DBE allows real time visualization of the entire small bowel, enabling endoscopic intervention and tissue acquisition from previously inaccessible areas. A study by Rahman *et al.* reported that 39% of patients were diagnosed with CD after DBE in whom the prior diagnosis was inconclusive with radiology and ileocolonoscopy (10).

Established Crohn's disease

Approximately 50% of patients with small bowel CD develop strictures during the course of illness, with overall progression of the disease in up to 70% over a 10-year period (11). Inflammatory strictures are managed with biologic and immunomodulator therapies while fibrotic strictures are managed with either surgery or endoscopic dilatation. DBE plays a key role in the management of stricturing disease and has an advantage over CE given that the risk of capsule retention is approximately 7% in this setting (12).

Luminal narrowing in stricturing CD may be associated with partial or complete small bowel obstruction. Surgical treatment of strictures involves either stricturoplasty or resection. Recurrent strictures may necessitate repeated resections, ultimately leading to short bowel syndrome. Some strictures may be managed by DBE, which allows endoscopic balloon dilation (EBD) of both native and anastomotic fibrotic strictures as an outpatient procedure. We recommend against EBD for strictures longer than 5 cm as there is an increased risk of perforation with increased stricture length. The technical success of EBD is defined as achieving an endoscopically passable residual stricture (13). EBD of strictures is often combined with quadrantic intralesional injection of steroids such as triamcinolone to reduce stricture recurrence (14,15). Prior biopsy confirmation of the benign fibrotic nature of the stenosis is recommended as, rarely, adenocarcinoma or lymphoma can cause stricturing disease. Strictures are sometimes associated with fistulae proximal to the obstruction due to the pressure effects upstream of the stenosed segment. Strictures associated with fistulae are best treated with surgery in our opinion.

Mucosal healing and histologic remission are increasingly being used as objective endpoints to determine the efficacy of medical treatment, along with non-invasive markers such as fecal calprotectin (16). DBE allows for visual confirmation of mucosal healing and for tissue acquisition to confirm histologic remission. In a study involving

82 patients with an established diagnosis of CD, the diagnostic yield was 87% when performed to investigate abdominal pain or anemia. These findings then influenced subsequent management decisions in 82% of patients. Among patients with suspected CD with inconclusive imaging, the yield was 79%; also, 77% of patients had treatment decisions altered because of the findings. Failure to reach the target area was seen in 17% of patients (12).

Small intestinal bleeding

About 5% of DBE examinations are for the investigation and management of recurrent or chronic obscure mid-gut bleeding, with a positive yield in 64%–92% of patients (17). Mid-gut bleeding is defined as small-bowel bleeding located between the papilla and the ileocecal valve (18). Bleeding may be due to a number of conditions, including vascular lesions, tumors, and inflammatory lesions.

DBE allows for diathermy utilising gold probe, cryotherapy, APC, and placement of haemostatic clips or injection of epinephrine. This is a cost effective treatment in patients with angiodysplasia of the small bowel. May *et al.* reported their experience of 50 patients with small bowel bleeding lesions treated with APC during DBE (19). Sixty percent of patients were transfusion-dependent before APC whereas this reduced to 16% post-APC. There was an increase in haemoglobin from a mean of 7.6 g/dL prior to endoscopic therapy to 11.0 g/dL following treatment over an average follow-up period of 55 months. However, there was recurrence of small bowel bleeding in 42% of patients treated with APC, necessitating repeated procedures.

A single-center, retrospective French cohort study of 261 patients demonstrated that endoscopic therapy using DBE for small bowel vascular lesions allowed long-term remission in more than half of the patients over a 3-year follow-up period. They found that increased number of vascular lesions and associated valvular or arrhythmic heart disease were independent predictors of rebleeding after initial intervention (20).

Shinozaki *et al.* reported 43 patients, who underwent 69 sessions of DBE endotherapy of small intestinal vascular lesions. Repeat DBE endotherapy resulted in an improved long-term outcome in patients with refractory bleeding over an average follow-up period of 4.9 years (21). However, Shimamura *et al.* cautioned against over-aggressiveness in performing DBE due to a high rebleeding risk with angiodysplastic lesions even after therapeutic intervention (22).

Role in celiac disease and malabsorption syndromes

Other indications for DBE are refractory celiac disease, severe iron deficiency anemia and unexplained gastrointestinal symptoms (23). Duodenal biopsy is sufficient to monitor mucosal recovery in asymptomatic celiac disease patients who have adequately responded to gluten free diet. However, patients with refractory celiac disease are at risk of developing enteropathy-associated T-cell lymphoma (EATL) or ulcerative jejunitis and DBE may have a role in diagnosis (24). EATL is more commonly seen in the distal small bowel unlike celiac disease, which predominantly affects the proximal small bowel. In a prospective study, Cellier *et al.* demonstrated that push enteroscopy with jejunal biopsies had a diagnostic value in 50% of patients with ulcerative jejunitis (25). Histologic lesions in celiac disease may be distributed discontinuously so occasionally, push enteroscopy may be used to evaluate celiac disease with exclusive jejunal distribution (26). The risk of small bowel malignancies in celiac disease is 20 to 60 times higher than that of the general population. In

elderly patients, lymphoma and small bowel adenocarcinoma may rarely be the presenting manifestation of celiac disease. DBE may be used in these situations when the index of suspicion for celiac disease is high to visualize and obtain a histologic diagnosis when traditional endoscopy fails (27). In the largest multi-center study on the outcomes of DBE in celiac disease, DBE helped in formulating a plan in 33% of 24 patients (28). This study included patients with refractory celiac disease, persistent iron deficiency anemia and those with poor compliance.

DBE allows detailed examination of the small bowel in patients with malabsorption of unclear origin. A study of 12 patients reported a diagnostic value of 42% (29). These patients all had normal duodenal biopsies taken during standard gastroscopy and were subsequently diagnosed with Crohn's disease, primary intestinal lymphangiectasia and jejunal amyloidosis on jejunal and ileal biopsies taken at the time of DBE.

Small bowel tumors

About 5% of GI tumors develop in small bowel (30). One unique role of DBE is in histologic diagnosis of small bowel tumours. These patients are usually seen for various symptoms attributable to the tumours and have undergone work up with either CE or imaging before considering DBE. In one study, malignant small bowel tumours were detected in 4.5% of 627 patients who underwent DBE for various reasons. Most were located in the jejunum and ileum. The most commonly diagnosed tumor was a GI stromal tumor (GIST) followed by small bowel adenocarcinoma (32). Tattooing of the lesion helps surgeon localize it better.

Balloon Assisted ERCP in patients with altered anatomy

Device assisted Enteroscopy (DAE) techniques have been recently developed for therapeutic enteroscopy, especially ERCP in altered anatomy. Patients with prior Roux-en-Y surgery have difficulty in biliary cannulation via endoscopic retrograde cholangiopancreatography (ERCP) with a success rate of only 33-67% due to the altered anatomy and bypass of the pancreaticobiliary portion of the GI tract (31). These patients have a high incidence of symptomatic gallstones. If they develop pancreaticobiliary obstruction they often require percutaneous biliary cannulation (Percutaneous transhepatic cholangiogram; PTC) or surgery.

DBE has provided an effective alternative in such settings. For the purpose of ERCP, Roux-en-Y has been divided into short (50cm) and long limb (>100cm) on one side and bilioenteric / pancreatoenteric anastomosis versus intact Vater's papilla on the other side (34). One study reported that ERCP at the level of the intact papilla in long limb Roux-en-Y was less successful (58%) as compared to short-limb or bilioenteric anastomosis (80%) (32). In a study involving 85 patients, DBE helped to access the bilioenteric anastomosis in 73% and ERCP with intervention was successful in 70% of such cases (31). Success was high in patients with native papilla (89%) compared to hepatico-jejunostomy (69%). Patients with a previous bile duct injury as the cause for Roux-en-Y had more success (94%) compared to gastro-jejunostomy patients (89%) and post-liver transplant patients (64%). Liver transplant patients with a second redo surgery (46%) and patients with childhood surgery (38%), especially the Kasai procedure (20%) had the lowest yield. PTC is technically difficult in non-dilated ducts, in the presence of

ascites, and does not allow access to the pancreatic duct.

A study reported an 87% success rate of DBE-assisted ERCP in Billroth Type II anatomy, with a 6.5% rate of complications, mainly perforation. Failure of ERCP in this study was due to inability to reach the papilla because of tumor obstruction or fixed peritoneal adhesions; failed cannulation; and failure to remove stones completely (32). The reasons for failure of DAE are related to 1. type of surgery often with insufficient knowledge of the altered anatomy prior to the index enteroscopy despite correlation with cross sectional imaging 2. longer channel length of 200 cm (needing dedicated accessories), a lack of side viewing enteroscope, elevator and a therapeutic channel (often 2.8mm compared to 4.2mm for the generic duodenoscope) 3. shortage of advanced endoscopists with training in DAE and finally 4. technically challenging, long procedure duration, low success rates, higher complication rates without additional remuneration(36). Use of a transparent cap (distal attachment) on the enteroscope helps to orient the scope and aids cannulation of an intact papilla(37).

A newly developed short DBE (EI-580BT, Fujinon) with a channel diameter of 3.2mm is promising for DBE assisted ERCP in surgically altered anatomy. The benefits of this short scope include use of traditional ERCP accessories, higher suction, advanced force transmission, adaptive bending and a smaller turning radius(38). This enteroscope is not yet widely available. In the above study, Tsutsumi *et al*. reported three patients in which they deployed multiple stents using double wire technique and placed self-expandable metal stents (SEMS) through the scope, safely and effectively. Pinho *et al*. demonstrated a technique of placement of SEMS for malignant biliary stricture in altered anatomy, using DAE-ERCP with standard enteroscope using a 'through-the-overtube and over-the-wire' technique(36).

DBE in the Elderly

Two studies have indicated the safety and efficacy of DBE in elderly patients over 75 years old (33, 34). Unlike younger patients who underwent DBE after an imaging abnormality, the most common reason for DBE in the elderly was obscure GI bleeding (14.6% of cases). Angioectasia was the most likely finding in such patients, which often needed therapeutic intervention (39% of cases). There were no major post-procedural complications reported. There was higher concordance between CE and DBE in this population. These studies concluded that DBE can safely be performed in the elderly despite a higher incidence of cardiac disease and anticoagulation treatment in this group.

Comparison of DBE with other imaging modalities

Prior small bowel imaging with CT or MRI is recommended before DBE to increase the diagnostic yield of DBE. A study had indicated that the rate of whole small-bowel visualization with single balloon enteroscopy (SBE) was inferior to DBE, mainly because of the enhanced stability offered by two balloons used in DBE (35). However, a recent meta-analysis involving 4 randomized trials showed no statistically significant difference between SBE and DBE(36). SBE is reported to be quicker and easier to learn (41). A comparison of SBE vs DBE is summarised in Table 1.

Properties	**DBE**		**SBE**
	EN-450T5	**EN-450P5**	
Outer diameter, mm	9.4	8.5	9.2
Working channel diameter, mm	2.8	2.2	2.8
Overtube width mm	13.3	12.2	13.2
Field of view	140^o	120^o	140^o
Price ($)	55,250	51,350	46,400
Length of the enteroscope	2300		2000
Overtube length, cm	140		132
Overtube balloon	Yes		Yes
Material of the balloon	Latex		Silicon
Use in latex allergy	No		Yes
Manufacturing company	Fujinon		Olympus
Depth of insertion (oral), cm	239±24.3		233±31
Percentage of achieving complete enteroscopy (%)	57		0
Diagnostic and therapeutic yield	Similar		Similar
Average Procedural times (oral) minutes	70		60
Learning curve	Longer		Shorter
Year introduced	2001		2007

Table 1 Comparison of single balloon and double balloon enteroscopes

DBE vs CE: In a prospective single-blind study by Kameda et al (37), the diagnostic yield of capsule (71.9%) was superior when compared to DBE (65.6%), though this was not statistically significant. The agreement between these modalities was 50% for vascular lesions and 100% for ulcerative and mass lesions.

DBE vs CT: CT is a non-invasive and rapid imaging modality and helps in the evaluation of the entire small bowel as well as extra-intestinal pathologies. It is limited by inability to obtain tissue samples. A study reported that overall detection rates for small bowel disease was higher with DBE (92%) than CT (55%) (38). Diagnostic yield was higher for DBE when compared to CT for inflammatory diseases, angiodysplasia and diverticulae, but not for gastrointestinal tumors/polyps (43). In clinical practice, we find that these modalities are complimentary, as CT can guide the best route for DBE.

DBE vs CT vs CE: All three modalities had comparable detection rate for small bowel tumours, though CE and DBE had higher

detection rates for occult GI bleeding sites than CT. Also, CE had higher rates of detection of angiodysplasia (38). The authors concluded that combining the three modalities would likely increase the detection rate of small bowel pathologies.

MRE vs DBE: In a study of 15 pts with Peutz-Jeghers syndrome, DBE detected more hamartomatous polyps >15mm (80%) when compared to Magnetic resonance enteroclysis (MRE) (62%), although the difference was not statistically significant. Complete bowel examination was achieved more with MRE than DBE as the prior surgeries in these patients made complete DBE challenging (39). In another study of 10 patients with suspected small bowel CD, MRE vs DBE was evaluated. DBE detected lesions in 50% of these cases and provided histological diagnosis. MRE detected superficial lesions in 30% of the patients in which DBE was normal. The authors concluded that MRE and DBE complement each other when evaluating small bowel CD (40).

Complications

Diagnostic DBE is considered to be relatively safe and feasible with low complication rates; however, therapeutic DBE is associated with a higher risk of complications compared to therapeutic colonoscopy (41). The overall complication rate of diagnostic DBE is around 0.8% to 1%, whereas the complication rate with therapeutic DBE is 3% -4% higher than therapeutic EGD or colonoscopy (42). Complication rates ranges from approximately 0.9% for APC to 10% for polypectomy (41). The major complications of DBE include perforation, bleeding and acute pancreatitis. Deep injury including exposure of the muscle layer has been most commonly noticed around the ligament of Treitz, due to the sharp angulation, although this is almost always managed conservatively (2).

Abdominal pain after the procedure has also been reported. Insufflation with carbon dioxide gas instead of air appears to be effective at reducing post-procedure abdominal pain (17). Although a rise in amylase and lipase is seen in a significant proportion of patients (30-50%) after undergoing DBE, only a minority of patients develop clinically relevant pancreatitis (0.3%). However, this is the most dreaded complication of DBE, and should be discussed while obtaining informed consent (43). It is believed to occur from mechanical straining (traumatic injury and/ ischemia) of the body and tail of pancreas (44). This is also noted to be more when the enteroscope makes a clockwise rotation(2). Factors such as the length of procedure, number of push and pull cycles and intense abdominal pain during the procedure have shown positive correlation with the incidence of pancreatitis (29). Splenic rupture with DBE has been documented as a case report (45).

For patients with a latex allergy, DBE should not be performed - SBE should be chosen as an alternative as the latter uses silicon overtube and non-latex balloon (36). Factors such as the experience of the endoscopist, shorter time of procedure, and inflating the balloons distal to the ligament of Treitz were found to reduce the rate of complications (46). The rate of missed small bowel lesions was as high as 24% in one study. Factors such as suboptimal cleansing, insufficient examination time, and small lesions in atypical locations were responsible for missed lesions (46).

Future of Double Balloon Enteroscopy

DBE has stood the test of time for over a decade since its introduction, despite the arrival of single balloon enteroscopes and

spiral enteroscopy. The motorized version of the original spiral enteroscope (currently withdrawn from the market) appears to be promising as per the interim analysis of the ENMSET trial(52). There has also been lot of progress on development of newer techniques for DAE including "on-demand enteroscopy" using the through-the-scope balloon (NaviAid AB balloon catheter) that is introduced through the working channel of a G-Eye Colonoscope (Smart Medical Systems, Ra'anana, Israel), which has a permanently integrated balloon at its tip. This has a shorter procedure duration, is better tolerated (even with conscious sedation) with reasonable yield and good safety profile, though the insertion depths are not comparable to "traditional" DBE.

With regards to newer indications, DBE has been used for colonoscopy (in incomplete colonoscopies), placement of jejunal feeding tubes, percutaneous endoscopic jejunostomy, for evaluation of the afferent limb and excluded stomach in surgically altered anatomy and for pediatric small bowel evaluation(55)(56). Pediatric DBE are also commercially available which have smaller caliber (EN-450P5/20 Fujinon) and more recently the ultra slim (7.5mm EN-580XP, Fujinon)(57). There have been several case series proving the safety and efficacy in children, though the risk of pancreatitis (roughly 2%) has been reported to be higher than in adults (0.3 – 1.0%) with antegrade balloon enteroscopy(58). DAE-ERCP (including direct cholangioscopy after sphincteroplasty) has been increasingly used for biliary access in surgically altered anatomy, reserving PTC as the final option. The future of this technique looks promising despite increasing use of endoscopic ultrasound (EUS)-guided biliary drainage to access the dilated intra-hepatic ducts via the left lobe of the liver.

Conclusion

DBE is a minimally invasive technique that allows diagnostic and therapeutic interventions in patients with small-bowel abnormalities, often suspected by other imaging modalities. Since the introduction of the initial concept in 2001 by Yamamoto *et a.l*, several models and prototypes of DBE have become available commercially. There have been many improvements in both the technique and design. There is always a constant need and desire to have slimmer scopes and larger channels since it has a wide range of therapeutic capabilities, with an acceptable risk-benefit profile, and is cost-effective when properly used by well-trained endoscopists. The challenge in the future will be to ensure that there are enough endoscopists trained in the future to deliver the service to patients.

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