Double-balloon endoscopy

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Bibliography
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Double balloon endoscopy (DBE) was developed for the examination of the small intestine. DBE together with capsule endoscopy have improved the endoscopic approach to the small intestine, and revolutionized the management of small-intestinal diseases. DBE features not only deep intubation of the small bowel, but also the improved control of the endoscope tip, even in the distal small intestine. This improved control is provided by stabilization from the overtube balloon. In this article, we explain how to use DBE effectively and safely. The basic principles of DBE are discussed as well as proper techniques, tips for effective insertion of the double balloon endoscope, proper indications of DBE, and endoscopic therapies in the small intestine.

Objectives

Endoscopic examination of the small intestine using conventional endoscopes is limited by the length of the instrument and difficulty in intubation. Double balloon endoscopy (DBE) was developed to enable deeper intubation of the small intestine [1].

DBE is indicated mainly for the diagnosis and/or treatment of small-intestinal disease. Endoscopic access to the distal small intestine, which is beyond the reach of conventional endoscopes, has been achieved using DBE. By using DBE, a detailed endoscopic examination can be carried out, including biopsy sampling. In some cases endoscopic treatment can be carried out immediately.

DBE has also been found to be useful when colonoscopy is difficult or unsuccessful. It may also enable access to the pancreatic or bile duct for endoscopic retrograde cholangiopancreatography (ERCP) in patients who have undergone Roux-en-Y reconstruction.

Basic principles

For the proper use of DBE, it is important to understand how DBE works. DBE enables deeper intubation of the small intestine by effective shortening of the intestine. In push enteroscopy, advancement occurs at the expense of constant stretching and lengthening of the intestine. The transmission of force to the endoscope tip diminishes, resulting in lack of advancement of the endoscope (**Fig. 1**, upper panel). DBE solves this problem by mounting a balloon onto a flexible overtube, which is passed over the scope. Once inflated, the balloon "grips" and holds the intestine in place, preventing stretching of the intestine. Consequently, advancement of the endoscope shaft does not stretch the intestine, and the pushing forces are more effectively transmitted to the endoscope tip [2] (**Fig. 1**, lower panel).

After the endoscope has advanced to the maximum extent possible, the balloon on the overtube is deflated and the overtube is advanced over the endoscope. During this maneuver the endoscope can slip back. To prevent this, a second balloon mounted on the distal end of the endoscope is inflated. Thus, two balloons are inflated in alternation to advance the endoscope through the small intestine.

The overtube has an added advantage in that it improves control of the endoscope tip in the small bowel. This is because the movement of the endoscope is controlled from the point where the intestine is gripped by the overtube balloon. This is particularly useful when performing targeted endoscopic treatment.

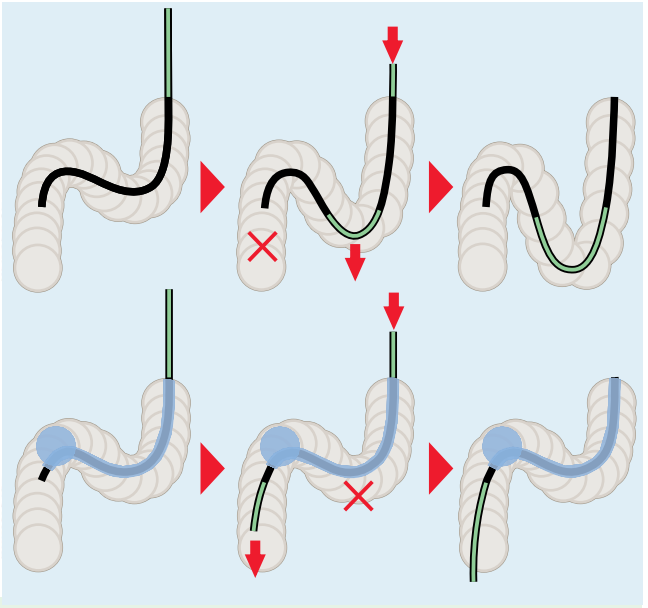

Fig. 1 Upper panel: Stretching of a curved intestine in push enteroscopy. Lower panel: Inhibition of intestinal stretching by the overtube with balloon attached.

Fig. **2** **a** Double balloon endoscopes (EN-450P5 and EN-450T5). **b** Balloon controller.

Material used

DBE system

The DBE system consists of a dedicated endoscope with a balloon mounted at its distal end, an overtube with a balloon, and a balloon controller to inflate or deflate the balloons (**Fig. 2**). Three types of dedicated endoscopes for the DBE system are currently available: diagnostic type (EN-450P5, Fujinon, Saitama, Japan); therapeutic type (EN-450T5, Fujinon); and a shorter version of the therapeutic type (EC-450BI5, Fujinon). The endoscopes of all three types have air channels for the balloons. They are used in combination with a flexible overtube, which has a balloon mounted at its distal end. The inner and outer surfaces of the tube are hydrophilic. Both endoscope and overtube balloons are made from latex, which is 0.1 mm thick and very soft. The balloons can be inflated or deflated by a dedicated balloon controller (PB-20, Fujinon) with one-touch controls, while monitoring the air pressure. The balloons are used at 45 mm Hg, which is the lowest pressure required to grip the intestine for endoscope insertion. Inflation at this pressure will not cause pain or discomfort to the patient.

The differences between the three types of DBE are in the length and diameter. The working length of EN-450P5 and EN-450T5 is 200 cm and the working length of EC-450BI5 is 152 cm. EN-450P5 is a thin endoscope with an external diameter of 8.5 mm, and a forceps channel diameter of 2.2 mm. Both EN-450T5 and EC-450BI5 have an external diameter of 9.4 mm and a forceps channel diameter of 2.8 mm.

The shorter DBE, EC-450BI5, is useful for colonoscopy and for ERCP in patients with Roux-en-Y anastomosis. Most of the accessory devices for colonoscopy and ERCP can be used with this endoscope.

Description of procedure

Preparation

DBE can be carried out from either the anterograde or the retrograde approach. For transoral insertion of the double balloon endoscope, about 12 hours of fasting is enough for bowel preparation because food residue usually reaches the large intestine by the time of the examination. However, transanal insertion requires bowel preparation similar to colonoscopy. Poor bowel preparation may result in the bowel contents seeping into the overtube, thereby increasing the friction between endoscope and overtube.

Sedation and monitoring

Because the small intestine is a long organ of about 6 m in length, the whole procedure of DBE may take longer than 1 hour, and it can give some discomfort to the patient. Therefore, appropriate sedation should be used for the procedure. The patient's condition should be closely monitored during examination, using a combination of pulse oximetry, automated sphygmomanometry, and electrocardiography.

Insertion technique

General principle

Techniques for DBE should enable the advancement of the endoscope tip with the minimum of force. Endoscope advancement is supported by the inflated overtube balloon; inflation is kept to a minimum to ensure safety. Forceful insertion withdraws the overtube rather than advancing the endoscope tip. The proper insertion force needs to be applied to advance the endoscope tip smoothly.

Forceful insertion of a sharply angled endoscope should be avoided. The operator should insert the endoscope while redu-

cing the angle as much as possible and swinging the tip so that the endoscope forms a large arc.

Air insufflation during insertion must be kept to a minimum. Air pockets will encumber pleating of the intestine over the overtube. Less air will also minimize patient discomfort. A short hood attached to the tip of the endoscope is useful to keep the tip a distance from the wall, and therefore reduce the need for air insufflation. The hood will also help to negotiate bends. The use of CO_2 instead of air for insufflation is also recommended.

Successful DBE requires an understanding of how the configuration of the endoscope and inflation of the balloon affect advancement. During training, fluoroscopic monitoring is very helpful. The configuration of the endoscope can be optimized under fluoroscopy by retracting the endoscope and the overtube with both balloons inflated. With experience, fluoroscopy can be used only when needed.

Specific procedures

Balloons on both the endoscope tip and the overtube are initially deflated, and the overtube is maximally retracted so that the length of the endoscope beyond the tip of the overtube is as long as possible. As for regular endoscopy, the initial insertion is carried out by the operator without the aid of an assistant. After the full length of the endoscope beyond the tip of the overtube is inserted, the assistant is positioned between the operator and the patient to hold the overtube straight.

Using the 155-cm marking on the endoscope (thick white line, **Fig. 3**) as a guide, the overtube is inserted until its rear end reaches the marking. At this position, the tip of the overtube is close to the balloon attached to the endoscope tip. It is important to gently advance the overtube so as to prevent it from catching the intestinal mucosa. Water can be injected into the overtube to optimize the lubricity between the overtube and the endoscope. The assistant should liberally inject water as needed. When insertion of the overtube is difficult, a jiggling technique may facilitate insertion.

After insertion of the overtube, the assistant holds and straightens the overtube. Both hands are used to keep the overtube straight, one hand held at the rear end of the overtube and the other close to the insertion orifice (mouth or anus). The operator manipulates the endoscope as it is advanced toward the rear end of the overtube.

The endoscope can be inserted about 30 – 40 cm with one insertion "stroke". The endoscope tip balloon is inflated to grip the intestine. Then, the assistant advances the overtube to the 155-cm mark. The overtube balloon is then inflated. A shortening maneuver is not necessary after the first insertion "stroke" (entry into the duodenum or the distal ileum by anterograde and retrograde approach, respectively).

The balloon on the tip of the endoscope is deflated for the second insertion stroke. The same sequence is then repeated. Shortening of the intestine is performed after advancement of the overtube towards the endoscope tip. With both balloons inflated, the endoscope is retracted together with the overtube. The segment of the small intestine through which the overtube has been inserted is pleated over the overtube and shortened effectively. Simultaneously, the next segment of the intestine becomes more accessible for intubation.

The endoscope can be inserted further through the small intestine by repeating the above procedure.

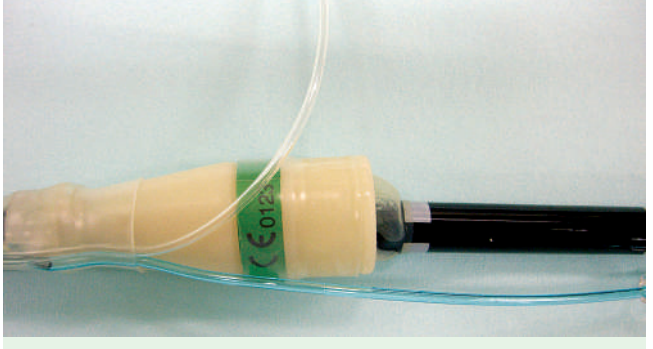

Fig. 3 Thick white line indicating the 155-cm marking on the endoscope.

Tips for retrograde insertion

Anal insertion of the double balloon endoscope is regarded as being more difficult than oral insertion, especially in Western countries [3]. Several factors can be considered responsible for this difficulty.

1. Bowel preparation. Polyethylene glycol + electrolyte solution is usually given for bowel preparation the night before the day of the procedure in Western countries. However, by the time of the procedure, mucus accumulates on the surface of the colon, which makes the balloons slippery. Therefore, it is better to give the solution in the morning of the same day of the procedure.
2. Insertion through the colon. Balloons should be used to grip the colon during the insertion of the endoscope through the colon. The DBE balloons are so elastic that they can be inflated as large as the size of the colon. It is difficult to insert the double balloon endoscope through the colon without using the balloons because the endoscope is too floppy to control in the colon. Air insufflation should be minimized to allow effective shortening of the colon and effective gripping of the colonic wall with the balloons.
3. Insertion through the ileocecal valve. A supine position is usually better than the left lateral position. If supine does not work, the right lateral position can be attempted. The overtube balloon should be inflated in the ascending colon. Gentle withdrawal of the overtube, which has gripped the ascending colon, may expose the ileocecal valve for easier intubation. After intubating the terminal ileum, the endoscope tip is immediately straightened. The endoscope tip should be advanced cautiously, without forceful insertion of the shaft, to prevent the tip from falling back into the colon.

Endoscopic therapies with DBE

Endoscopic therapy using standard colonoscopy accessories is possible using the therapeutic type of DBE. Therapy includes hemostasis with clips (Quick Clip HX-201UR and EZ Clip HX-610, Olympus, Tokyo, Japan; Resolution Clip 2261, Boston Scientific, Natick, Massachusetts, USA), and argon plasma coagulation (APC) (APC 300 and Erbotom ICC 200, Erbe Elektromedizin, Tüebingen, Germany), polypectomy, endoscopic mucosal resection (EMR), balloon dilation (CRE™ Wireguided Balloon Dilator, Boston Scientific), stent placement, and retrieval of foreign bodies. In the small intestine, we carry out APC with the argon gas flow rate at 2.0 L/minute, and the electric current at 40W.

In order to obtain the maximum control of the accessories during endoscopic therapy, the endoscope shaft should be maximally straightened before passing the accessory. This is possible by gently pulling and shaking the endoscope shaft with both the

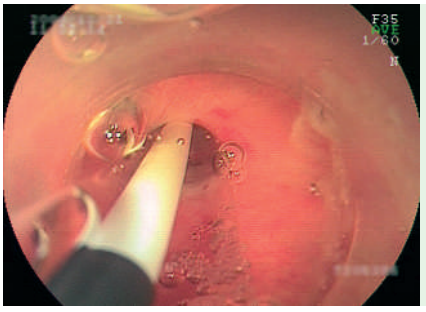

Fig. 4 A 4-mm transparent hood mounted to the tip of the endoscope helps to maintain the endoscopic view during balloon dilation of a hepatojejunostomy stricture.

balloons inflated to grip the intestine near the lesion. When the insertion of accessory devices is difficult due to looping of the endoscope, a small amount of olive oil can be injected through the accessory channel for lubrication. Many types of endoscopic therapies become easier with a 4-mm transparent hood mounted to the tip of the endoscope. The hood minimizes the need for air insufflation and maintains the endoscopic view by keeping the endoscope tip a fixed distance from the target (**Fig. 4**). Because the intestinal wall is thin, careful attention should be paid to prevent complications, such as perforation, when performing endoscopic therapies. Submucosal injection of 0.001% saline–epinephrine is useful for the prevention of bleeding and perforation.

Limitations and success rate

Insertion difficulty

DBE can be difficult and the intubation depth more limited in patients with adhesions of the intestine. Adhesions hamper effective pleating of the intestine over the endoscope, thus preventing shortening. The diagnostic type of endoscope (EN-450P5), with a smaller and more flexible shaft, is preferable for patients with intestinal adhesions. Gentle and cautious advancement is required.

Success rate of total inspection of the intestine

Endoscopic inspection of the entire small intestine is possible with DBE, but usually requires sequential anterograde and retrograde intubations. Success rates of total inspection of the intestine are reported to be around 80% in Japan [4]. The rate is lower in Western countries. This difference is mainly due to lower success rates for retrograde intubation of the small bowel.

Diagnostic yield

Diagnostic yield of DBE for obscure gastrointestinal bleeding has been reported to be 43% to 80%, and mostly 70% to 80% [3–8].

Impact on management of small-intestinal diseases

DBE enables endoscopic treatment of small-intestinal diseases that historically required open surgery. For example, endoscopic hemostasis and accurate diagnosis of the bleeding source may avoid surgical exploration and possible resection of the intestine (**Fig. 5**). Endoscopic polypectomy in the small intestine has dramatically changed the management of patients with Peutz–Jeghers syndrome. Endoscopic dilation of small-intestinal strictures may avoid or reduce the number of surgical resections (**Fig. 6**).

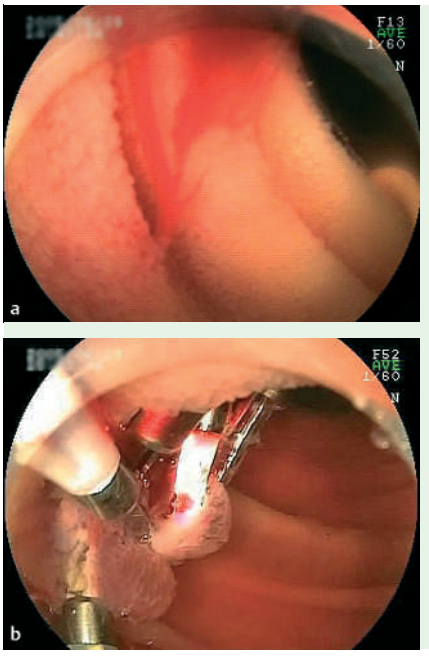

Fig. 5 **a** Identification of the bleeding point with observation under water. **b** Endoscopic hemostasis with clip placement.

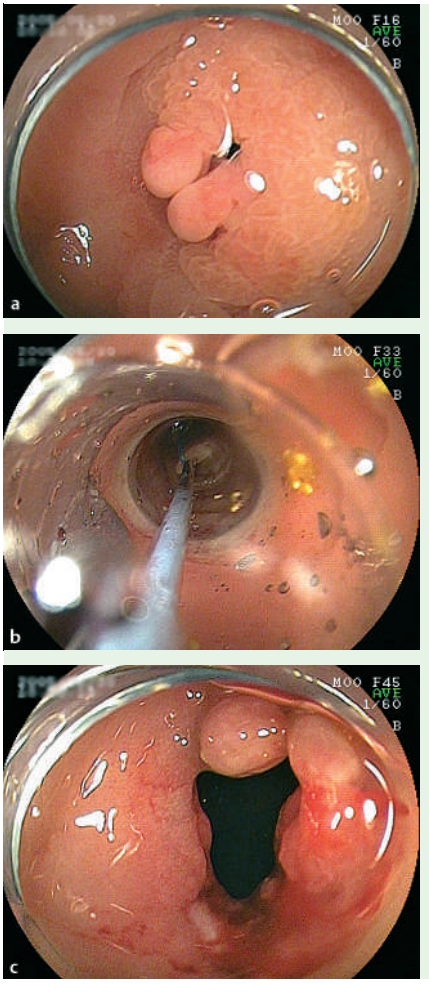

Fig. **6** **a** Anastomotic stricture in a patient with Crohn's disease. **b** Balloon dilation using a controlled radial expansion balloon catheter (CRE™ Wireguided Balloon Dilator, Boston Scientific). **c** Endoscopic view after the dilation.

Even in diseases that require surgical resection for curative therapy, such as small-intestinal tumors, early detection and accurate diagnosis by DBE may improve the prognosis of the patients.

Complications and safety

In a multicenter survey on DBE by Mensink et al., DBE was found to be a safe procedure with low complication rates. The overall complication rate in diagnostic DBE was 0.8 %, which was comparable with complication rates observed in diagnostic colonoscopy (0.02 % – 2.4 %). The complication rate in therapeutic DBE was 4.3 %, which was higher than that associated with therapeutic colonoscopy (1.2 % – 2.0 %). This report confirmed that acute pancreatitis was of major concern in patients undergoing DBE, and occurs following 0.3 % of DBE procedures [9]. The mechanisms of developing pancreatitis after DBE are not well understood. Some authors hypothesize that it is caused by an increase in duodenal intraluminal pressure during the procedure, leading to reflux of duodenal fluids into the pancreatic duct [10]. Others speculate that post-DBE pancreatitis is caused by repetitive mechanical strain on the pancreas because the inflammatory changes typically occur in the body–tail region of the pancreas [11].

Indications

The following indications have been proposed in the consensus report of the 2nd International Conference on DBE [12].

Necessary

- Mid-gastrointestinal bleeding: in patients with suspected mid-gastrointestinal bleeding (bleeding source not identified by conventional upper gastrointestinal endoscopy and colonoscopy), in patients with known mid-gastrointestinal bleeding for endoscopic hemostasis.
- DBE following capsule endoscopy: in patients in whom a further diagnostic test (e. g. biopsy sampling) or therapy is indicated.
- Endoscopic diagnosis and treatment of stenoses: endoscopic or histologic diagnosis in patients with suspected stenoses, balloon dilation for stenoses of the small intestine.
- Tumors and mass lesions: endoscopic diagnosis and histologic confirmation of tumors or masses detected by other imaging modalities if considered necessary prior to surgery; preoperative marking (e. g. tattooing) in patients with discrete findings who are scheduled to undergo surgical endoscopic resection of suitable lesions in the small intestine.
- Removal of foreign bodies from the small intestine (e. g. retained capsule endoscope).

Appropriate

- Endoscopic and histologic diagnosis of Crohn's disease involving the small intestine, and subsequent follow-up.
- Endoscopic and histologic diagnosis of obstruction, including intussusception, and unexplained complications of small-bowel diseases.
- Endoscopic access in postoperative anatomy, including ERCP after Billroth II or Roux-en-Y operation (**Fig. 4**); postbariatric surgery access to the biliary tree or gastric remnant.
- In difficult colonoscopy cases.

Inappropriate

- Contraindications for DBE are essentially similar to conventional upper gastrointestinal endoscopy and colonoscopy, especially when considerable risk of perforation is expected due to a fragile intestinal wall.
- Functional abdominal pain without evidence of iron deficiency anemia, hypoalbuminemia, positive fecal occult blood, inflammatory laboratory changes, or obstructive symptoms.

Competing interests: H. Yamamoto has applied for a patent in Japan for the double balloon endoscopy described in this manuscript.

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