Review Article

Small bowel intervention and application of enteroscopy for altered small bowel anatomy—endoscopic advanced therapy using double balloon enteroscopy

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ABSTRACT

The management of patients with small bowel obstruction distal to the third part of the duodenum and altered gastrointestinal anatomy is challenging. Until recently, surgery had been the mainstay of treatment for obstruction, which had however posed a risk of serious complications. The difficulty with the endoscopic approach in the deep area of the intestine and the blind end of the altered gastrointestinal anatomy could be a possible reason. Recently, the advent of overtube-assisted endoscopy has radically facilitated endoscopic interventions such as balloon dilation for benign obstructions or placement of self-expanding metal stents for malignant obstructions. Advanced endoscopic therapy for small bowel stricture or choledochojejunal anastomotic stricture has become a safe and effective method.

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Introduction

Small bowel strictures are common and when they occur can be an important cause of morbidity. The causes of small bowel strictures include Crohn's disease (CD), nonsteroidal anti-inflammatory drugs (NSAIDs), and choledochojejunal anastomosis, and can be neoplastic, postsurgical, or idiopathic. Clinical dilemmas often arise in determining whether a stricture is present, what the degree or severity is, and the nature of the stricture. Small bowel obstruction (SBO) can cause secondary extrinsic or intrinsic lesions of the bowel wall. Extrinsic lesions due to adhesions (most commonly postoperative) frequently cause a bowel obstruction. Intrinsic causes include inflammatory (e.g., CD), ischemic, small intestinal and choledochojejunal anastomosis, NSAID-induced, radiation-induced, and malignancy.

The endoscopic approach is a safe and feasible alternative to surgery for selected cases, however, the anatomy of the small intestine or the inability of conventional endoscopes to reach a specific area can technically make it challenging or preclude the procedure. Therefore, surgery had historically been the only treatment option until recently. However, these patients are not usually suitable candidates for surgery, and a less invasive treatment is ideally required. Surgery is not advisable in a patient with choledochojejunal anastomotic stenosis due to obstructive jaundice; in such a case, endoscopic intervention is important.

Since double balloon endoscopy (DBE) was first described by Yamamoto et al1 in 2001, access to small bowel and altered gastrointestinal anatomy, such as the afferent loop, has much improved. DBE is useful for performing endoscopy because it provides the ability to perform a biopsy, define the stricture, perform balloon dilation, and place stents. DBE is the method of choice in our hospital. Herein we review DBE-assisted interventions for the management of SBOs.

Overtube-assisted endoscopy (deep endoscopy)

The introduction of DBE followed by the subsequent development of single balloon endoscopy (SBE) and spiral overtube-assisted endoscopy (SE) have significantly impacted the diagnosis and therapy of diseases involving the small intestine.2,3 In terms of insertion techniques, balloon-assisted enteroscopy (BAE) such as DBE and SBE entail a similar mechanism of advancement consisting of sequential bowel pleating by a push–pull technique that uses a
balloon-fitted overtube with or without a second balloon inserted over the tip of a dedicated endoscope.\(^4,5\)

By contrast, SE or rotational endoscopy uses a spiral or raised helix-fitted overtube coupled with an endoscope that is advanced as a unit into the small bowel by continuous rotation of the overtube in a manner similar to use of a corkscrew. An inner sleeve allows the independent motion of the overtube from the endoscope during advancement and withdrawal. The difference regarding insertion between BAE and SE is that the latter uses a more or less continuous pleating of the small bowel by a clockwise rotation of the overtube rather than the push–pull technique of the former.\(^6\)

As for the overtube placement technique, there is a difference among DBE, SE, and SBE. SBE and SE allow an easy withdrawal of scopes with an overtube remaining in the intestine, whereas DBE requires a little trick to do so.\(^7\) With DBE, withdrawal of the scope through an overtube can be problematic causing a loss of the overtube position due to a force required to disrupt the rubber band that fixes the balloon at the tip of the endoscope; however, instead of the rubber band, the balloon can be fixed alternatively with a thread, which enables the retraction of the endoscope into the overtube without losing the double balloon maneuvers.

Thus, every endoscope brings its own feature although all three modalities are equally safe and effective for the evaluation of the small intestine.\(^8,9\) In Japan, SE is not commonly used; however, BAE is widespread and frequently applied. The selection of an endoscope is influenced primarily by device applicability and the endoscopist’s preference.

### Identifying small bowel strictures

Once a small bowel stricture or a choledochojejunal anastomosis stricture is suspected, a precise description and diagnosis are necessary for adequate treatment. Small bowel stricture is determined based on the results of previous investigations [capsule endoscopy, computed tomography (CT) scan, magnetic resonance cholangiopancreatography (MRCP)] and clinical findings, although endoscopic diagnosis is necessary for the final decision. After a DBE has been inserted at the lesion site, a biopsy and/or contrast imaging of the digestive tract is frequently required for small bowel stricture, as well as endoscopic retrograde cholangiopancreatography (ERCP) for choledochojejunal anastomosis stricture. As a general endoscopic treatment, balloon dilation for benign strictures and stent placement for malignant strictures is applied.

### Balloon dilation

DBE facilitates a careful inspection of the stricture allowing back and forth movement of the endoscope enabling biopsies for histologic evaluation as well as injecting contrast media under fluoroscopy to better define its dimensions. Balloon dilation is also operable for treatment as an alternative to surgery.\(^10–12\) It can be performed using balloon dilating catheters through-the-scope (TTS) or over-the-wire (OTW). The TTS technique tends to be the mainstream method for both small bowel stricture and choledochojejunal anastomosis stricture.

**Balloon dilation in patients with normal anatomy**

There has been a few previous case series using DBE to treat benign small bowel strictures of various etiologies.\(^13–15\) According to these reports, success rates ranged from 58% to 100%. Our overall success rate with balloon dilation for small bowel strictures was 97.2% (35/36), and the etiological cause was CD in most of the cases. In our hospital, the TTS technique was applied to perform dilation from 12 mm to 13.5 mm (Fig. 1). Almost all the cases were successful, although in one case a severe perforation occurred after dilation that required emergency surgery.

Irani et al\(^20\) reported a single severe adverse event (also a perforation) in a patient with radiation enteritis. In summary, endoscopic dilation is an effective treatment for benign small bowel strictures of various etiologies providing an alternative to surgery, although the risk of severe adverse events has to be considered and close monitoring of the patient is necessary.

### Stent placement

Self-expanding metal stents (SEMSs) are an effective modality for palliating malignant gastrointestinal obstruction.\(^22\) SEMSs were originally introduced for the treatment of malignant biliary obstruction, and were subsequently introduced for esophageal use. Although SEMSs have been used to treat obstruction of the upper gastrointestinal tract, colon, and rectum,\(^23–26\) not many papers were written about its application for small bowel strictures. Until recently, evaluation of the small bowel had been difficult due to its length, complicated angulation, and limited ability of endoscopes. Therefore, SEMS placement into the small bowel is challenging.

**Small bowel stents in patients with normal anatomy**

Malignant SBO is a common and distressing complication that occurs particularly in patients with bowel diseases or gynecologic cancer. Although surgery is normally the first-line treatment for patients with malignant SBO, patients with prognostic criteria such as intra-abdominal carcinomatosis, poor performance status, or massive ascites should not be referred for surgical intervention.\(^27\)

In patients for whom surgery is not advisable, SEMSs have recently become the primary treatment modality for malignant gastrointestinal obstruction owing to its noninvasive feature and application.\(^28,29\) However, because of the technical limitations of conventional endoscopes and delivery systems, palliation of malignant SBO by endoscopic placement of SEMSs is usually challenging.\(^27\)

Several attempts have been made to outline how palliation of malignant SBO by endoscopic placement of SEMSs can be performed. First, the use of an adult colonoscope was attempted. Jeurnink et al\(^10\) reported that enteral stent placement could be successfully performed employing a colonoscope in 16 patients with a malignant obstruction at the distal duodenum or proximal jejunum. In
Fig. 1. (A) Small bowel stricture. (B) Balloon dilatation of small bowel stricture. (C) Balloon dilation was successful. (D) Oozing was found post balloon dilatation.

Fig. 2. (A) Choledochojejunal anastomotic benign stricture. (B) A dilation catheter was used to dilate choledochojejunal anastomosis. (C) Balloon dilatation of choledochojejunal anastomotic stricture. (D) Balloon dilatation was successful.
their study, technical and clinical success rates were 93%, and no major complications were reported.

Second, Lee et al.\textsuperscript{31} reported the withdrawal–reinsertion technique using DBE. This technique is an advancement of DBE and balloon-assisted reduction maneuvers to reach the obstructed site. It involves the passage of a long guidewire through the stricture, and the withdrawal of the endoscope with the guidewire remaining in the lesion site. Then, a conventional endoscope is re-inserted over the guidewire as distally as possible, and TTS SEMS placement is performed followed by stent deployment under the control of endoscopic and fluoroscopic views. They attempted this method in 19 consecutive patients with malignant SBO at the site of the efferent jejunal loop after gastrectomy, the proximal jejunum, and the third duodenal portion after failing to place SEMSs using conventional endoscopy. The technical and clinical success rates were 95% and 84%, respectively. No major complications were observed during the procedure. Stent migration and restenosis occurred in 11% and 21% of patients, respectively. However, the disadvantage of this technique is that there is a risk of losing the guidewire during withdrawal and insertion actions to switch scopes. Therefore, this
technique seems to be more suitable for proximal small bowel strictures than obstructing lesions in the mid/distal jejunum or farther.

Third, a through-the-overtube SEMS insertion technique using a deep enteroscope was attempted. This technique involves the advancement of a deep endoscope with an overtube to the dedicated site\textsuperscript{17,32–38} confirming the stricture by contrast imaging, advancement of the guidewire beyond the site of stricture, withdrawal of the endoscope with the overtube remaining inside, advancement of stent delivery systems over the guidewire through the overtube under fluoroscopic guidance, and stent deployment over the stricture. This method was introduced by Ross et al\textsuperscript{32} using DBE. Subsequently a similar technique using SE and SBE was reported.\textsuperscript{33,34} Although this technique shows great potential as a treatment for deeper small bowel strictures, only numerical data from a small case series was available. Further investigation and assessment is necessary to evaluate this method.

In our hospital, we use the through-the-overtube technique using short-type DBE for endoscopic placement of SEMSs for SBO. Our success rate for endoscopic placement of SEMSs was 100% (5/5). In one case, we performed a modification of the through-the-overtube and withdrawal–reinsertion techniques. The overtube was retained inside with the guidewire, the scope was withdrawn, and then the SEMS was inserted along the guidewire. Up to this it was a normal procedure, however, we installed an ultra-slim endoscope in the overtube, which enabled direct observation, and the stent was released (Fig. 4). The advantages of this method are that insertion of the ultra-slim endoscope can prevent loss of the guidewire upon re-insertion and deployment of the stent under direct view of the endoscope is possible. In summary, although the primary treatment for SBO is surgery, SEMS placement is an effective method for inoperable cases. The advent of overtube-assisted endoscopy has almost resolved the problem of the limited ability of conventional endoscopes. Delivery systems are still problematic and require the inventive use of currently available deep endoscopy instruments and SEMS not specifically suited for that purpose. The development of new endoscopes that allow TTS stent placement and/or novel highly flexible stent designs compatible with current endoscopes will facilitate endoscopic stenting of the mid gut, with the application extending beyond palliation in the foreseeable future.

**Biliary stents in patients with altered gastrointestinal anatomy**

Conventional ERCP has been widely applied to pancreatobiliary disease cases in patients with normal anatomy,\textsuperscript{39,40} however, it has been challenging to perform in patients with altered gastrointestinal anatomy. Success depends on the surgical method, but many cases are unsuccessful.\textsuperscript{41} The most common reasons for lack of success are the inability of the endoscope to reach the surgical pancreatobiliary anastomosis as a consequence of the length of the bowel passage and severe angulation that cannot be traversed safely (some acute angles of surgical limbs are difficult to navigate). As a result, many patients with altered gastrointestinal anatomy are referred for surgical or percutaneous interventions, which have greater complications than endoscopic therapy.\textsuperscript{42} Recently, the efficacy of ERCP using DBE (DB-ERCP)\textsuperscript{42–47} and SBE (SB-ERCP)\textsuperscript{47–50} has been widely reported, however unavailability with other devices due to their working channels and lengths is yet to be overcome. Using a short-type DBE can overcome the problem of

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**Fig. 5.** (A) Malignant choledochojejunal anastomotic obstruction (endoscopic view). (B) A SEMS was inserted into the biliary duct (endoscopic view). (C) The deployment of the covered metallic stent (endoscopic view). (D) Cholangiography was performed using a catheter (fluoroscopic view). (E) The guidewire was advanced into the biliary duct and deep cannulation (fluoroscopic view). (F) The covered metallic biliary stent was placed (fluoroscopic view). SEMS = self-expanding metal stent.
working length, although a 2.8-mm working channel confines itself to less available biliary stents. Generally, covered metallic biliary stents are not applicable with a device with a 2.8-mm working channel, although from our experience, they can be used in some situations with the help of some endoscopic tricks as shown in Fig. 5. The success rate of endoscopic placement of SEMSs for malignant choledochojejunal anastomotic obstruction was 100%. In summary, DB-ERC is an effective modality for malignant choledochojejunal anastomotic obstruction. Yet, the available types of SEMSs are limited and the development and improvement of devices is urgently needed.

Conflicts of interest

All contributing authors declare no conflicts of interest.

References