Total enteroscopy with a nonsurgical steerable double-balloon method

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Background: **Deep insertion of an enteroscope by use of a push technique is difficult. A new method of enteroscopy was developed, a double-balloon method, to improve the access to the small intestine.**

Methods: **The new method uses 2 balloons, one attached to the tip of the endoscope and another at the distal end of an overtube. By using these balloons to grip the intestinal wall, the endoscope can be inserted further without forming redundant loops in the small intestine. This method was tried with a standard upper endoscope in 3 patients and with a longer enteroscope in 1 patient.**

Results: **Despite its short length the upper endoscope was successfully inserted as far as 30 to 50 cm beyond the ligament of Treitz in the 3 patients. In the fourth patient the longer enteroscope was successfully inserted beyond the ileo-cecal valve.**

Conclusions: **The double-balloon method facilitates endoscopic access to the small intestine.**

Received May 16, 2000. For revision August 8, 2000. Accepted October 12, 2000.

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Presented in part at the annual meeting of the American Society for Gastrointestinal Endoscopy, May 2000, San Diego, California.

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 0016-5107/2001/$35.00 + 0 **37/69/112181**

doi:10.1067/mge.2001.112181

Although the quest to inspect the mucosal surface of the small intestine began early in the fiberoptic era, insertion techniques currently in use are far from ideal. The most frequently used method is push enteroscopy. However, deep insertion of an enteroscope is difficult with this method because the force applied to advance the instrument is diminished by the tortuous small intestine. Moreover this causes tremendous discomfort to the patient. Therefore, even with a new-generation video-push enteroscope along with an overtube, the depth of insertion is at most 160 cm beyond the ligament of Treitz, which is far less than the length of the small intestine, which is approximately 14 feet (430 cm).[1-3]

At present, intra-operative enteroscopy is the most reliable procedure for total visualization of the small intestine.[2,4] In this method, passage of the enteroscope is assisted by the surgeon during open laparotomy. Although the technique is not difficult, an endoscopist and surgeon are needed to perform the procedure. The biggest disadvantage of this method, however, is its invasive nature.

Nonsurgical total small bowel enteroscopy has been successfully accomplished by 2 different methods,[3] one using an instrument pushed over a previously passed guide-string[5-7] whereas the other relies on peristalsis to propel a long, flexible fiberoptic endoscope through the intestine.[8,9] Both methods are tedious, uncomfortable, and time consuming. The guide-string for the "ropeway" method may take several days to pass from mouth to rectum.[3] Stretching of the string can damage the small bowel mucosa and cause tremendous pain and discomfort that necessitates the use of general anesthesia. The limitations of

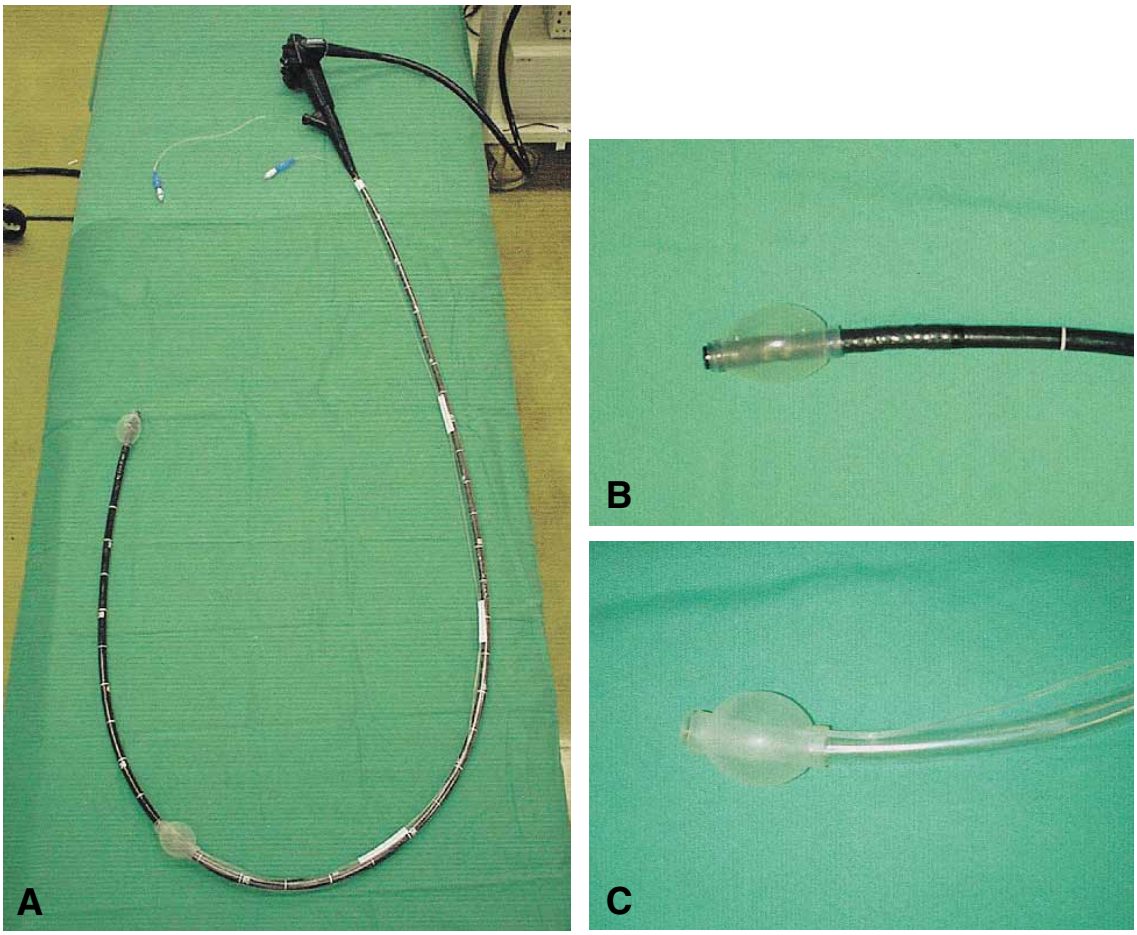

Figure 1. A, Video endoscope (SIF-Q240, Olympus) with balloon attached at tip and handmade overtube with another balloon attached in place on the insertion tube. **B,** Cylindrical balloon attached at tip of enteroscope. **C,** Distal end of overtube with attached balloon.

Table I. Characteristics of patients and procedures

Patient	Age (y)	Gender	Indication	Sedation	Scope	Depth of insertion	Findings	Complications
1	41	M	GI bleeding	None	XP-240	30 cm beyond LT	Bleeding hemangioma	None
2	14	F	GI bleeding	Diazepam 7.5 mg i.v.	XP-240	30 cm beyond LT	Bleeding hemangioma	None
3	78	F	Protein losing enteropathy	Diazepam 5 mg i.v.	XP-240	40 cm beyond LT	Benign stricture	None
4	69	F	GI bleeding	Diazepam 15 mg i.v.	SIF-Q240	Up to cecum	Meckel's diverticulum	None

i.v., Intravenous injection; *XP-240,* Olympus XP-240; *SIF-Q240,* Olympus SIF-Q240; *LT,* ligament of Treitz.

the "sonde" procedure are the lack of both tip deflection and intervention capabilities.[2,3] Despite the ability to inspect the entire small bowel, neither method has gained general clinical acceptance.

Because each of the currently available methods has limitations, the development of relatively noninvasive and steerable enteroscope with intervention capability, which can explore the entire small bowel, would be highly advantageous. Therefore, a new method of small bowel enteroscopy was developed, a double-balloon method that allows access to the entire small intestine with intervention capability.

PATIENTS AND METHODS

Between June 29 and December 3 of 1999 the new method of enteroscopy was attempted in 4 patients. Full

Figure 2. Plain x-ray of the abdomen showing the tip of the enteroscope beyond the ileo-cecal valve.

and informed consent was obtained from each patient before the procedure.

Instruments

A videoendoscope (XP-240, Olympus Optical Co., Ltd., Tokyo, Japan) with a working length of 103 cm and an outer diameter of 7.7 mm was used for the procedure in the first 3 patients. A cylindrical silicone balloon with the length of 40 mm was attached to the tip of the endoscope. A handmade overtube of vinyl chloride equipped with another balloon (40 mm length) at its distal end was also used to assist in the insertion of the endoscope. It was 12 mm in outer diameter and 75 cm in length.

For the last patient a video enteroscope (SIF-Q240, Olympus) with a working length of 200 cm and an outer diameter of 9.8 mm was used with a balloon (40 mm length) attached at its tip. The overtube with a balloon (40 mm length) for this instrument was 14 mm in outer diameter and 140 cm in length (Fig. 1).

Procedure

The overtube is back-loaded onto the endoscope prior to intubation after lubrication of its inner surface with K-Y Jelly (Johnson & Johnson, Ltd., Maidenhead, United Kingdom). The intubation is started with both balloons deflated. When both balloons reach the duodenum, the balloon on the overtube is inflated to fix the tube to the intestine. The endoscope is inserted further while holding the overtube in place. When the tip of the endoscope is inserted as far as possible, the balloon on the endoscope tip is inflated, the balloon on the overtube is deflated, and the overtube is advanced along the endoscope. When the distal end of the overtube reaches the end of the endoscope, the balloon on the overtube is inflated to fix a second point to the intestine. At this point gentle withdrawal of the overtube with the balloon inflated causes pleating of the intestine onto the overtube, which prevents looping of the endoscope. The sequence is repeated each time with effective pleating of the intestine. Approximately 20 to 30 mL of air are used to inflate the balloons up to 30 to 35 mm in diameter. The pressure in the balloon can be monitored by feeling the tension in the air insufflation bulb attached to the air tube near the outer port. The volume of insufflated air is controlled according to the pressure and by noting whether the patient experiences discomfort. The procedure is performed under fluoroscopic guidance.

RESULTS

Four patients underwent the double-balloon method of enteroscopy (Table 1). The endoscope could be advanced without difficulty in all 4 cases. Despite the short length of the upper endoscope, it was successfully inserted as far as 30 to 40 cm beyond the ligament of Treitz in the first 3 patients. Bleeding points were identified in the first 2 patients and a stricture of the intestine was observed in the third.

In the fourth patient the tip of the enteroscope was inserted beyond the ileo-cecal valve (Fig. 2), and the mucosal surface of the entire small bowel was inspected. The time required to reach the cecum was 2 hours. In this case a diverticulum with a healing ulcer at its edge was found at about 100 cm orad to the ileo-cecal valve (Fig. 3). A diagnosis of Meckel's diverticulum was made and the ulcer was diagnosed as the source of the bleeding.

All 4 patients tolerated the procedures well and there were no complications.

DISCUSSION

The value of endoscopic exploration of the small bowel has been well documented. Established indications for small-bowel enteroscopy include unexplained digestive bleeding, radiographic abnormalities of the small intestine, and chronic diarrhea or malabsorption.[1,2,10]

At present, the most effective procedure for complete visualization of the small intestine is intraoperative enteroscopy. Fiberoptic endoscopes were used intraoperatively in the 1970s.[4] No major advancements regarding insertion technique have been made since that time except for a notable modification in which laparoscopic assistance is used for insertion.[11] Although laparoscopically assisted enteroscopy is less invasive than intraoperative enteroscopy, it still requires general anesthesia and both a surgeon and an endoscopist.

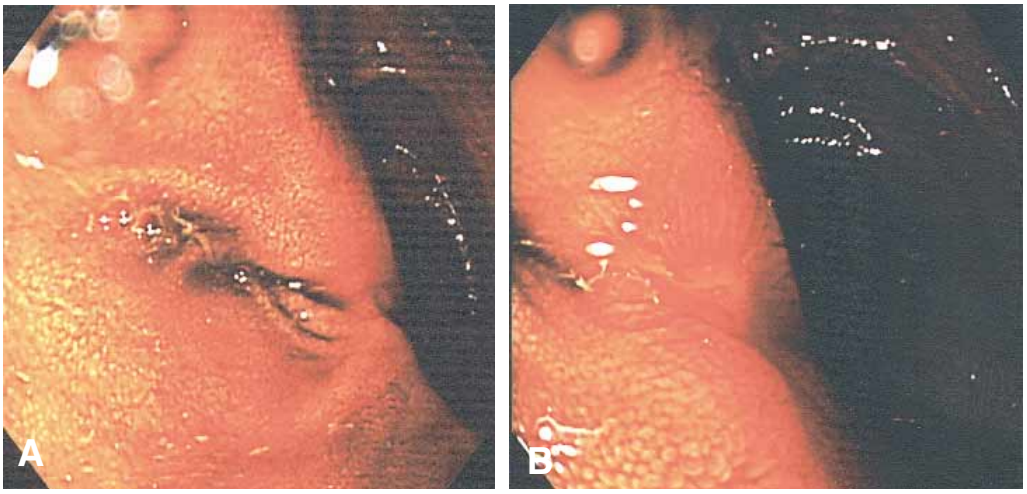

Figure 3. A, Endoscopic view of the Meckel's diverticulum. **B,** Small healing ulcer at distal edge of the diverticulum.

The "ropeway" method was first described in 1972.[5-7] However, it has been virtually abandoned due to its complexity and unpredictable outcome. The "sonde" method was also first described in 1972[12] and there have subsequently been some improvements in the instrument and the technique.[9] However its use is also becoming more and more limited because of certain crucial problems, including the lack of tip deflection, the lack of intervention capability, and the inability to readvance the instrument once withdrawal has begun.

Our new double-balloon method could be considered a modification of the push method. However the technique for the advancement of the instrument is different. In push enteroscopy, deep insertion of the enteroscope is limited by the formation of loops of small intestine that absorb the force exerted to advance the instrument. To permit deeper intubation of the small intestine a semi-flexible overtube has been used to maintain a straight instrument configuration and prevent bowing in the stomach. However the real reason for the difficulty is not the loop formation itself but the elastic nature of the looped intestine. In our method the role of the flexible overtube with a balloon was not to keep the insertion tube of the instrument straight, but to prevent stretching of the shortened intestine. Redundant instrument loops can easily be reduced and the intubated intestine is shortened by gentle withdrawal of the endoscope while the balloon at its tip is inflated to grip the intestine. The shortened intestine with a minimum of loops is maintained by the overtube. As long as stretching of the intubated intestine is prevented, the endoscope tip can be advanced by pushing it through the overtube. With this method, excessive stretching of the intestine is prevented and forceful straightening of the stomach and intestine is not necessary; hence the procedure can be performed safely and with a minimum of patient discomfort. The endoscope for the double-balloon method need not be as stiff as that used for the push method nor as long as that required for the "sonde" method. With an instrument about the length of the standard push enteroscope, the entire small intestine can be observed by using this method.

There were some concerns about the function and the effects of the balloons. If the expanding pressure against the intestinal wall is too great, it can cause patient discomfort or pain and even damage to the intestinal wall. However if the pressure is too low the balloon might not grip the bowel wall effectively. In our experience the balloon grips the bowel wall effectively with enough gentle pressure that was tolerable for the patients. For effectiveness and safety, a low compliance balloon should be used for this method to hold rather than dilate the intestine. The pressure was monitored by feeling the tension in the air sufflation bulb attached to the air tube near the outer port. To make the system safer, the safe and effective range of balloon pressure needs to be determined and it should be controlled with an accurate monitoring system. In this method, observation of the mucosal surface can be repeated, going forward and backward, over a range of about 50 cm from the point fixed by the balloon. This can be done at any point in the intestine. Because an endoscope with an accessory channel and tip deflection capability is used in this technique, therapeutic interventions are possible as well.

There is a report of similar instruments used for colonoscopy by Sugarbaker et al. in 1985.[13] They used a 2-cuff system with a movable sleeve that was tested in 3 patients. Although they reported that the 2 cuffs, sleeve, and control apparatus functioned as expected,

total colonoscopy was not achieved in any patient because the cuffs appeared to grip improperly and rupture. The concept for the advancement of the instrument tip in their system was an earthworm-like movement created by the 2 cuffs. The sleeve was used for the cuff movement. Therefore, 1 movement stroke in this system was equivalent to only 5 cm. In contrast, the overtube with a balloon in our system was used to prevent stretching of the shortened intestine. The insertion stroke in our method was about 50 cm with the Olympus SIF-Q240 enteroscope.

It is possible that the double-balloon method could significantly change the endoscopic approach to the small intestine. Because the endoscopes used in this method have intervention capability and tip deflection, endoscopic treatments for lesions at any level in the small intestine could become feasible. Several medical conditions such as bleeding, mucosal neoplastic lesions, and benign strictures of Crohn's disease in the distal small intestine, which presently require surgical treatments, are good candidates for the nonsurgical endoscopic treatments with this new double-balloon method. Perhaps this method of enteroscopy will provide easier access to the final frontier of endoscopy.

REFERENCES

1. Landi B, Tkoub M, Gaudric M, Guimbaud R, Cervoni JP, Chaussade S, et al. Diagnostic yield of push-type enteroscopy in relation to indication. Gut 1998;42:421-5.
2. Waye JD. Enteroscopy. Gastrointest Endosc 1997;46:247-56.
3. Lewis BS, Waye JD. Total small bowel enteroscopy. Gastrointest Endosc 1987;33:435-8.
4. Zaman A, Sheppard B, Katon RM. Total peroral intraoperative enteroscopy for obscure GI bleeding using a dedicated push enteroscope: diagnostic yield and patient outcome. Gastrointest Endosc 1999;50:506-10.
5. Hiratsuka H, Hasegawa M, Ushiromachi K, Endo T, Suzuki S, Nishikawa F, et al. Endoscopic diagnosis of the small intestine. Stomach Intestine 1972;7:1679-85.
6. Deyhle P, Jenny S, Fumagalli J, Linder E, Ammann R. Endoscopy of the whole small intestine. Endoscopy 1972;4:155-7.
7. Classen M, Frühmorgen P, Koch H, Demling L. Peroral enteroscopy of the small and the large intestine. Endoscopy 1972;4:157-62.
8. Tada M, Akasaka Y, Misaki F, Kawai K. Clinical evaluation of a sonde-type small intestinal fiberscope. Endoscopy 1977;9:33-8.
9. Tada M, Kawai K. Small bowel endoscopy. Scand J Gastroenterol 1984;19(Suppl 102):39-52.
10. Gay G, Lapuelle J. Guidelines of the French Society of Digestive Endoscopy (SFED) on Enteroscopy. Endoscopy 1998;30:641-2.
11. Ingrosso M, Prete F, Pisani A, Carbonara R, Azzarone A, Francavilla A. Laparoscopically assisted total enteroscopy: a new approach to small intestinal diseases. Gastrointest Endosc 1999;49:651-3.
12. Shinya H, Wolff WI. Fiberoptic endoscopy of the entire small and large intestine. 2nd European Congress of Digestive Endoscopy, Paris 1972.
13. Sugerbaker PH, Penland WZ, Lyddy J. Pneumatic device for the automated advancement of the fiberoptic endoscope for total colonoscopy—a preliminary report. Gastrointest Endosc 1985;31:210-3.