



# Small-Bowel Endoscopy

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## 7.1 Introduction

Over the past decade, advances in endoscopic equipment and techniques have allowed diagnostic and therapeutic advancements in the management of small-bowel disorders previously unreachable by standard upper and lower digestive endoscopy [1–4]. The advent of wireless capsule endoscopy (WCE) and balloon-assisted enteroscopy (BAE) between 2000 and 2001 has made the visualization of the entire small-bowel tract easier [5], becoming an attractive diagnostic imaging modality in children for low invasiveness and the absence of ionizing radiation. The inability to obtain tissue samples and to perform intervention has limited the use of WCE [1, 6]. The subsequent advent of BAE has permitted to achieve total small-bowel evaluation, combining both antegrade and retrograde procedures.

## 7.2 Technical Features

### 7.2.1 WCE

The first capsule model was approved by the FDA in 2001, while pediatric use was approved in 2004 and in 2009, respectively, for children between 10 and 18 years old and for all patients over the age  $\geq 2$  years [7, 8]. The capsule wireless system consists of three components: the endoscopic capsule, the recording system (sensors applied to patient's abdomen and data recorder that is held inside a wearable

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belt), and the workstation, where images are downloaded. Real-time visualization software and reconstruction of intestinal transit times are also available. More recently, machine learning algorithms (MLAs) have been proposed to automatically read endoscopic features, and they seem to be as effective as human readers in the diagnosis of small-bowel angioectasias [9].

### **7.2.2 BAE**

Two endoscopes for BAE are currently available: the double balloon enteroscope (DBE—Fujinon Inc. Saitama, Japan), and the single balloon enteroscope (SBE—Olympus, America Inc.). DBE has been first described in 2001, and the first pediatric reports have been reported in 2003 [3, 5, 10]. DBE uses an enteroscope with an inflatable balloon at the distal tip, whereas SBE uses an enteroscopy with no balloon. Both enteroscopes have a length of 200 cm and an outer diameter of 9.4 mm (with operating channel of 2.8 mm); the overtube is 140 cm long and runs on the instrument through a thin film of water that is introduced before performing the procedure to reduce the friction.

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## **7.3 Exam Preparation and Execution**

### **7.3.1 Informed Consent/Refusal [11]**

Informed consent in procedural-based medicine is mandatory. It is the tool by which the physician speaks to the patient or patient's surrogate (parents or caregiver in pediatrics) to inform them about a procedure and subsequently obtain legal and ethical permission to perform it. It is recommended that the general indications, methods, risks, benefits, and alternatives to WCE or BAE should be highly explained to the subject and/or appropriate surrogate/caregiver. The benefits of performing WCE or BAE compared with other alternatives should be discussed, and finally the risks of both techniques should be disclosed to the family.

### **7.3.2 Training/Certification [1, 11]**

Universally agreed guidelines for competency in performing advanced endoscopy, such as BAE or WCE, have not been formulated yet. Pediatric gastroenterology training programs do not routinely teach WCE or BAE. There is a wide number of in-person and online training courses endorsed by national or international gastrointestinal societies, whose efficacy has not validated. A minimum of 10–30 WCE are required for trainees to attain competence in WCE. No similar studies about BAEs exist, but some authors suggest a minimum of 20 procedures.

### 7.3.3 WCE [11–14]

The preparation to perform WCE has not yet been standardized in pediatric population, and there is no strong evidence of which is the best method. The tendency is to perform also an iso-osmolar laxative preparation. The capsule activates just as it is removed from the package and can be swallowed spontaneously by the patient or inserted through endoscopy. Younger children, or patients with difficulty in swallowing, may be trained at home with hard candies, which have approximately the same size as the capsule. A variety of accessories have been used to deliver the capsule endoscope in the stomach or in the small intestine, such as polypectomy snares and nets (both off-label). Only one licensed, dedicated device (US Endoscopy, Mentor, Ohio, USA) is available; that allows the release directly into the duodenum. This procedure requires general anesthesia with airway protection (orotracheal intubation, laryngeal mask).

### 7.3.4 BAE [2, 4, 6, 10, 13, 15, 16]

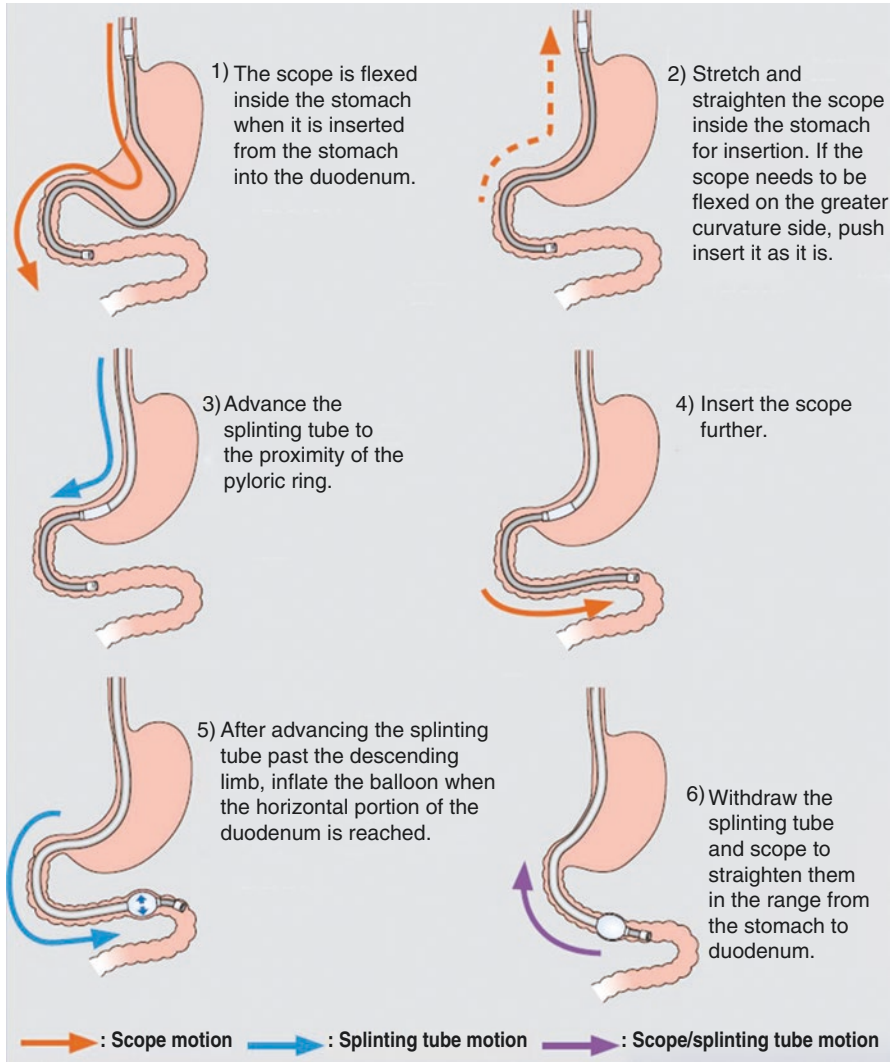
Preparation consists of a water diet in the 12–24 h before the procedure and absolute fasting in the previous 4 h; if it has been chosen an anal approach, the preparation for a conventional colonoscopy could be a solution. A general anesthesia with orotracheal intubation is strongly recommended, and it is advisable to use fluoroscopy especially in the early stages of the operator's learning. Both DBE and SBE use an overtube that has a balloon at the distal extremity; by inflating the balloon on the overtube, the small bowel can be reduced and straightened. This straightening facilitates further advancement of the enteroscope, whereas the overtube prevents undesired looping during the procedure. In the DBE, the balloon at the tip of the enteroscope is inflated to anchor the scope in place, whereas the overtube is subsequently advanced before the next reduction. The whole procedure is summarized in Figs. 7.1, 7.2, and 7.3. Choosing which approach to use (anterograde or retrograde) is primarily guided by previous examinations (i.e., entero-MRI), while the absence of indications or lesion locations may suggest to start with an oral approach.

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## 7.4 Indications

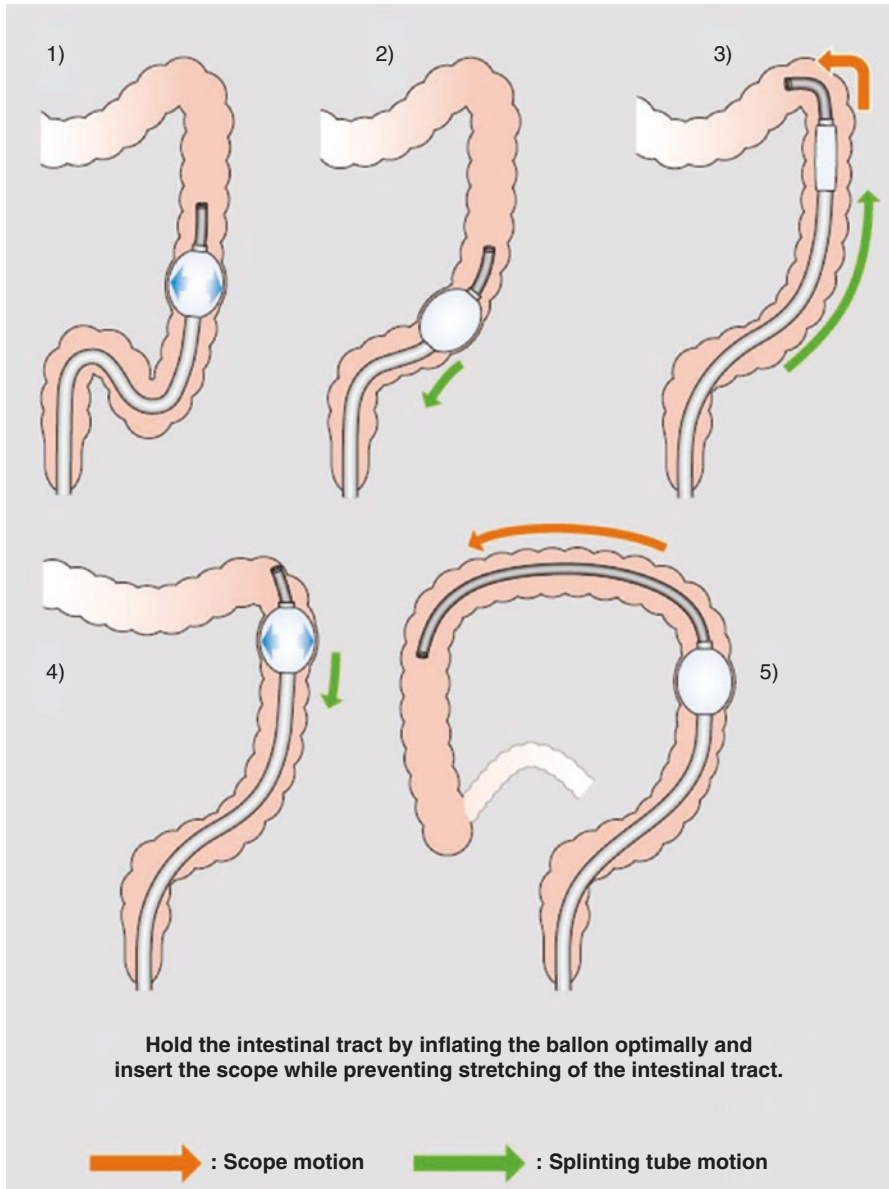
WCE and BAE share most of all indications but there may be some difference [10]. Main indications for both techniques in pediatric age is known or suspected IBD.

Conventional upper and lower intestinal endoscopy usually allows a definite diagnosis of IBD, and both WCE and BAE have a limited role in the initial evaluation of patients with known or suspected CD [10, 15]. WCE is indicated, if needed, as first-line enteroscopic tool for small-bowel evaluation and meets several indications: differential diagnosis between ulcerative colitis (UC), CD and unclassified IBD (IBDU); differential diagnosis with other pathological conditions, such as polyps, Meckel diverticulum, intestinal duplications, angiodysplasias, and other



**Fig. 7.1** Balloon-assisted enteroscopy passing through the stomach and duodenum

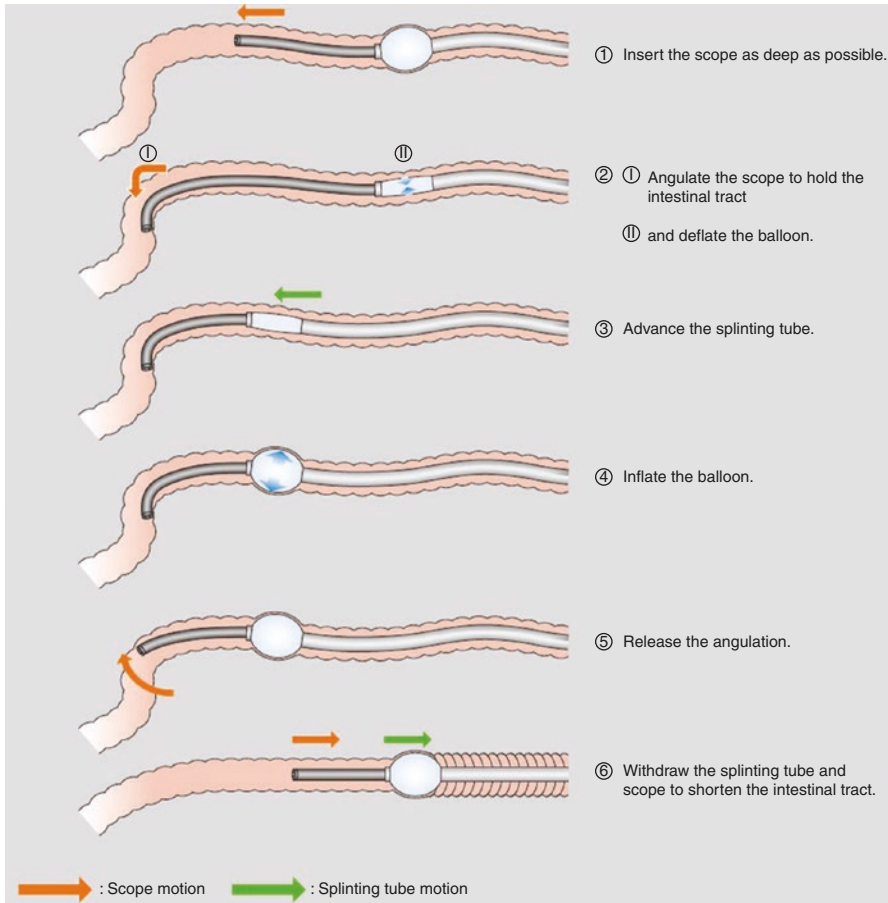
vascular malformations; staging of suspected CD with a normal traditional endoscopy; in known CD with unexplained signs or symptoms; surveillance of possible surgical complications (i.e., anastomotic ulcers); monitoring mucosal healing [3, 5, 17–19]. BAE shares with WCE the indications mentioned above; it is also indicated to perform biopsy in case of lesions identified with the WCE. If entero-MRI has already evidenced stenosis/strictures or lesions that deserves histological characterization or a therapeutic intervention (stopping a bleeding, CD-related stenosis/strictures dilation, removal of retained capsule), BAE is of first choice, avoiding the



**Fig. 7.2** Balloon-assisted enteroscopy passing through the colon

WCE [4, 5, 10, 20]. A proposed diagnostic-therapeutic algorithm for CD is reported in Fig. 7.4.

OGIB is defined as a bleeding of unknown origin that persists or recurs, after negative initial evaluation using bidirectional endoscopy and small-bowel imaging. Incidence is low in pediatric age presents a lower incidence because acquired

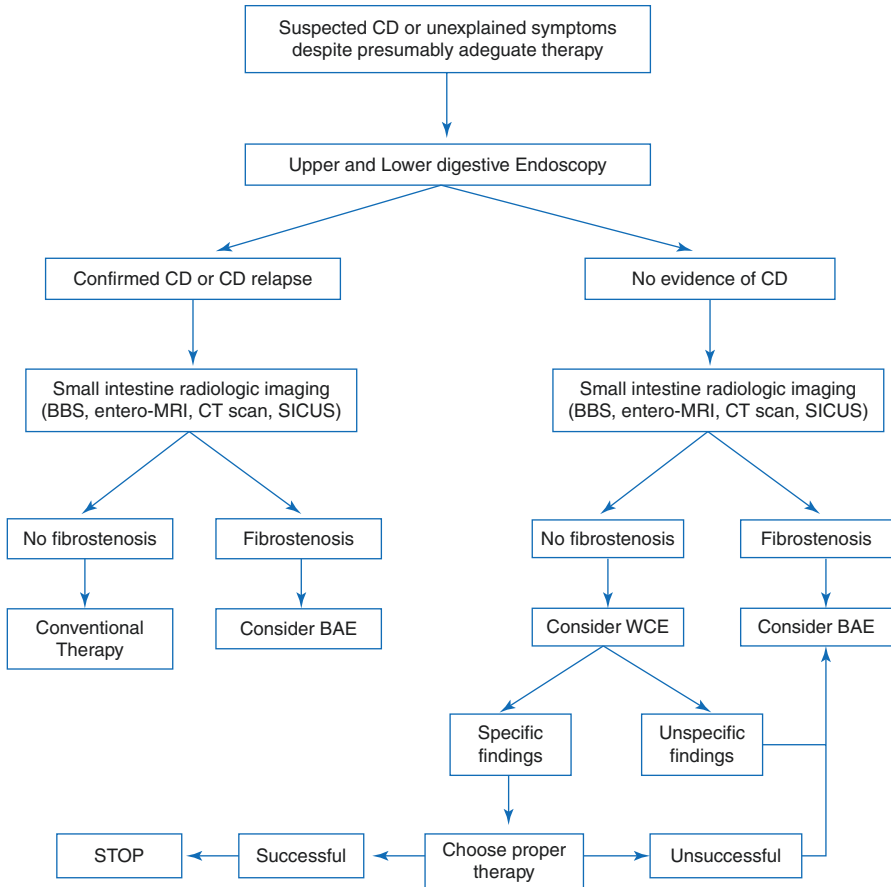


**Fig. 7.3** Principles of insertion and retraction

angiodysplasia and neoplastic pathologies of the small intestine are infrequent in this age group. In adults with OGIB, diagnostic comparison between WCE and BAE revealed no significant difference regarding the diagnostic yield and supported a combined use of both modalities; however, the same conclusion in pediatric patients cannot be obtained due to a lack in pediatric literature [10, 14, 17, 21]. OGIB and unexplained anemia may be the first symptom of an ileal CD or surgical complications.

## 7.5 Contraindications

Patient selection must be rigid: patients should undergo to high and low endoscopic examination and imaging of the small intestine to exclude digestive tract lesions that could represent a contraindication (see below) [6, 11, 14].



**Fig. 7.4** A proposed algorithm for the evaluation of suspected or relapsed CD (revised from [1, 13]). *BBS* barium series studies, *entero-MRI* entero magnetic resonance, *CT scan* abdominal contrast enhanced computed tomography, *SICUS* small-intestine contrast ultrasound, *WCE* wireless capsule endoscopy, *BAE* balloon-assisted enteroscopy

**7.5.1 WCE [3, 7, 8, 11, 12, 14, 22]**

Relative contraindications of WCE include any condition in which obstruction, strictures, or fistulae are suspected, which could cause WCE retention, and are listed in Table 7.1. In adults, a patency capsule (PC) is swallowed before the formal WCE study, in order to establish luminal patency and minimize the risk of capsule retention; the PC is not equipped with a camera but is radiologically identifiable and it is absorbable in 36–48 h if not expelled. Younger children cannot swallow the PC and sedation only for endoscopic placement of the PC is not recommended: it is suggested to perform a small-bowel anatomical study (BSS, CT scan, or entero-MRI) to help in predicting the risk of capsule retention, especially in high-risk patients. Normal imaging, however, does not obviate the risk of capsule retention.

**Table 7.1** Contraindications for BAE and WCE in pediatric age

Balloon-assisted enteroscopy		Wireless capsule endoscopy
Absolute	Related	
<ul style="list-style-type: none"> <li>– Intestinal perforation</li> <li>– Peritonitis</li> <li>– Septic state</li> <li>– Hemodynamic instability</li> </ul>	<ul style="list-style-type: none"> <li>– Age or weight</li> <li>– Thrombocytopenia or coagulopathy</li> <li>– Severe neutropenia</li> <li>– Recent digestive surgery or adhesions</li> <li>– Intestinal occlusion</li> <li>– Vascular aneurysms</li> </ul>	<ul style="list-style-type: none"> <li>– Bowel obstruction (Suspected or known)</li> <li>– Bowel strictures</li> <li>– Bowel fistula</li> <li>– Age or weight</li> <li>– Allergy to materials</li> <li>– Presence of pacemaker or other electromagnetic device</li> </ul>

There is no weight or age limit to perform WCE in children, even in <2 years old WCE is off-label. With the endoscopy-assisted placement of the WCE, studies have been successfully performed in children as young as 10 months and 7.9 kg, but the size of patient and the size of oral and pharyngeal tissues may pose a limitation; thus, caution should be approached when placing WCE in such small children. Other studies have proposed 11.5 kg as lower weight and 18 months as lower age to perform WCE.

### 7.5.2 BAE [6, 13]

Absolute contraindications are intestinal perforation or peritonitis, a septic state and/or an hemodynamic instability. Related contraindications are listed in Table 7.1.

It has not been well established which are the minimum weight and/or age to perform the exam; to date, BAE seems feasible in children as young as 3 years and as small as 13 kg, but there are only few, mostly retrospective, available data on a small number of patients. Moreover, appropriately sized endoscopes for even smaller sized patients are not available yet.

## 7.6 Complications

### 7.6.1 WCE [2, 3, 6–8, 13, 14, 22, 23]

WCE is generally a well-tolerated and safe procedure. Minor complications include skin or mucosal irritation, vomiting, pain, sore throat, missed lesion, or equipment malfunction. The most serious complication that may occur during the examination is the capsule retention, which has been defined as a WCE remaining in the intestinal lumen for 2 or more weeks or as a WCE that has required directed therapy to aid its passage. Unless a patient is symptomatic, the first clue of a retained capsule is the discovery of an incomplete study, in which the capsule does not reach the cecum at the conclusion of the study. In cases where the capsule retention in the intestinal lumen occurs for more than 15 days or becomes symptomatic, a surgical or endoscopic removal is mandatory, even if it has been described a spontaneous capsule evacuation after 3 months of retention.



### 7.6.2 BAE [2, 3, 6, 17, 24]

The lower number of complications with BAE is mainly due to the few pediatric cases; two recent pediatric studies demonstrate that SBE is safe and well tolerated. Common complications include perforation, pancreatitis, and bleeding, and are noticeably more frequent in patients with adhesions, altered intestinal anatomy or repeated procedures (i.e., in polyposis syndromes). Minor complications, such as self-limited abdominal pain and/or distension, sore throat, nausea, have the same frequency than with conventional gastroscopy and colonoscopy examinations.

## 7.7 Limitations

The main WCE limitations are the inability to wash and aspirate secretions in the lumen, and the inability to obtain biopsies; the latest guidelines suggest that CD diagnosis should never be made only on the results of a WCE test [18]. Principal limitation in BAE is due to the operator experience; hence, it is important to emphasize that these procedures should be performed in third-level pediatric centers by highly specialized and qualified personnel [1].

### Conclusions

WCE and BAE are newer endoscopic modalities that have improved both diagnosis and treatment of small-bowel pathology in pediatric patients [7]. WCE is a very useful approach to children presenting symptoms suggesting IBD, as a third-stage examination after conventional upper and lower GI endoscopy [9, 10]. In presence of small-bowel stenosis on radiologic imaging, BAE may allow both diagnosis and therapeutic treatment and may avoid a surgical intervention. BAE is more invasive and less safe than WCE. It shows therapeutic advantages in IBD, such as the possibility to place tattoos, perform hemostasis, dilate CD strictures and stenosis, and remove foreign bodies (including retained capsules) [15]. The diagnostic capability of the two BAE instruments (DBE, SBE) seems to overlap, so the choice is guided mainly by operator experience. WCE use is suggested as a first-line study in patients with a negative previous workup for CD (including upper and lower endoscopy and small-bowel imaging tests), and then BAE, if needed (Fig. 7.4). BAE could be used as a first-line technique if a pathological study has showed a WCE contraindication or if an endoscopic therapy is needed (i.e., strictures dilatation, hemostasis) [1, 13, 18, 25]. WCE and DBE may be performed in tandem, with initial WCE findings directing the choice of antegrade versus retrograde DBE approach. Recent results show how the two techniques combined can be complementary and fill the limits of each other.

Future studies, comparing WCE and BAE and defining their precise role, would clarify the diagnostic and therapeutic algorithms for management of IBD and other small-bowel diseases in children.

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