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# Role of Intraoperative Endoscopy in the Management of Small Bowel Diseases

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and Houssein Ammar*

## Abstract

With the advances in the endoscopic technology, most of the small bowel diseases are being diagnosed by capsule endoscopy and device assisted enteroscopy. However, there are many clinical situations such as small bowel obstruction, foreign body impaction where these advanced endoscopic procedures cannot be performed. In such cases, intraoperative endoscopy plays a vital role in the management of these small bowel diseases. Intraoperative endoscopy is also very useful in identification of the site of obscure gastrointestinal bleeding in difficult cases. Moreover, capsule endoscopy and device assisted enteroscopy are expensive procedures and not readily available at all medical centers especially in low income countries. On the other hand, intraoperative endoscopy can be easily performed by conventional gastroscope and colonoscope. In this chapter, we have discussed the indications, techniques, outcomes and complications of intraoperative endoscopy in the current era of deep enteroscopy.

**Keywords:** intraoperative endoscopy, enteroscopy, inflammatory bowel disease, Peutz-Jeghers syndrome, Crohn's disease

## 1. Introduction

Traditionally, intraoperative endoscopy (IOE) was the only means for the visualization of small bowel mucosal lesions not accessible to upper gastrointestinal endoscopy and colonoscopy. However, with the advances in abdominal imaging and the advent of capsule endoscopy (CE), the use of IOE diminished. A comparative study of CE and IOE found the sensitivity and specificity of CE to be 95% and 75%, respectively [1]. Hence, most guidelines recommend CE for detection of suspected small bowel lesions in patients with obscure gastrointestinal (GI) bleed. However, the main disadvantage of CE was inability to perform therapeutic procedures. Subsequently, the device assisted enteroscopy (DAE), namely, spiral endoscopy, double balloon enteroscopy (DBE) and single balloon enteroscopy (SBE) was developed which has brought paradigm shift in the treatment of small bowel mucosal diseases. DAE allows visualization, biopsy and removal of the small bowel mucosal lesions.

However, IOE is still an indispensable tool for the evaluation and treatment of small bowel diseases in special situations and institutions with lack of DAE

Advantages of IOE	Disadvantages of IOE
Complete bowel examination is possible in same sitting	Anesthesia and laparotomy related complications
The procedure is safe as it is performed under direct vision	Enterotomy related complications
Allows peritoneal, mesentery and omental examination and biopsy, if required	Availability of the endoscopy equipments and endoscopist at the time of surgery
Allows definitive treatment of the disease in the same sitting	Inability to negotiate the endoscope in case of dense bowel adhesions
Minimizes the number of procedures and enterotomies in patients with multiple lesions like PJS	Inability to visualize the mucosa in case of massive bleeding

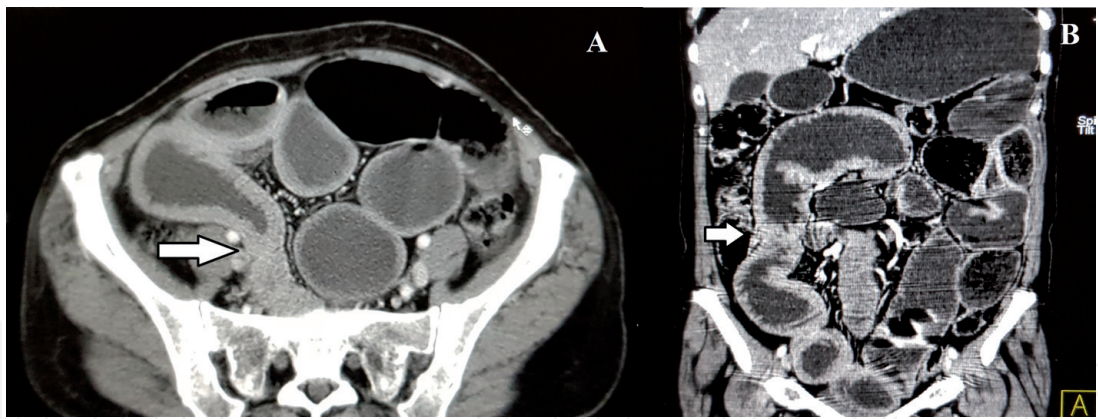
**Table 1.**  
*Advantages and disadvantages of intraoperative endoscopy.*

facilities. The reported success rate of IOE to achieve complete enteroscopy ranges between 57–100% in different series [1–10]. The advantages and disadvantages of IOE have been summarized in **Table 1**.

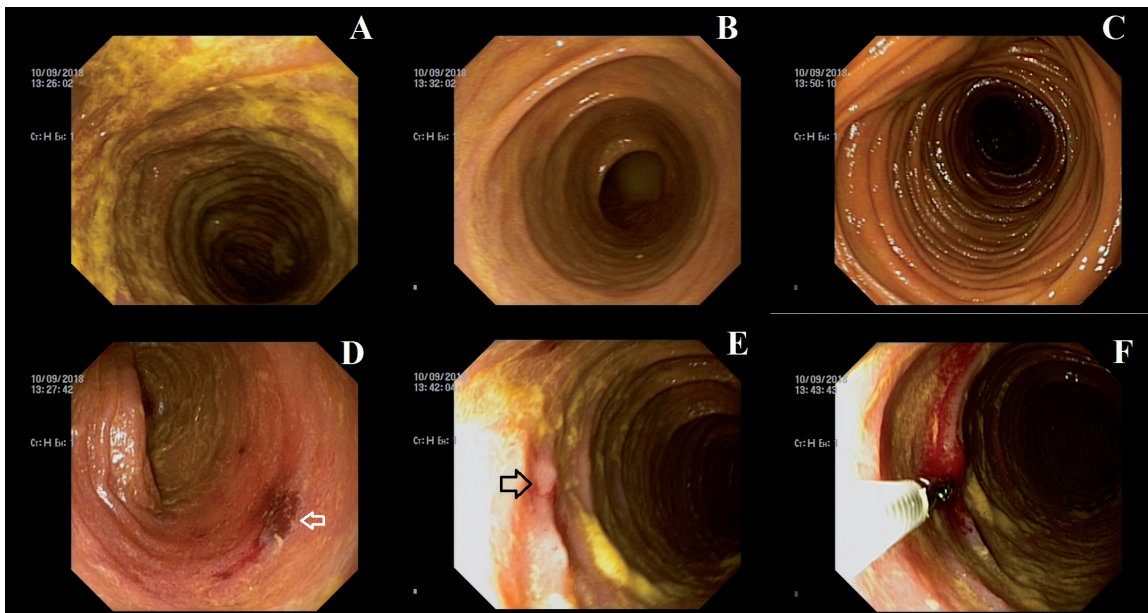
2. Indications

In the current era, despite the widespread use of DAE, IOE plays an important in the management of various GI disorders. In a 10-year study by Kopacova et al., the authors performed IOE in 41 patients with the commonest indication being obscure gastrointestinal bleeding followed by Peutz-Jeghers syndrome (PJS) [6]. The indications of IOE in the present scenario are as follows:

- **Obscure gastrointestinal bleeding** – It is recurrent or persistent bleeding from the unknown source in the GI tract that could not be identified on conventional endoscopy, colonoscopy and barium studies or enteroclysis [11]. Small bowel lesions account for 45–75% cases of obscure gastrointestinal bleed [11, 12]. In such cases, extensive investigations including enterography using computed tomography (CT) or magnetic resonance imaging (MRI), CE, DBE and RBC scan can often help in identifying the lesion (**Figure 1**). However, sometimes it is not possible to identify the site and cause of GI bleed in such patients despite exhaustive work-up. IOE is very helpful in detecting the mucosal lesions within the small bowel of patients with GI bleed (**Figure 2**). In a recent series of 67 patients with GI bleed, CE, colonoscopy, upper gastrointestinal endoscopy and DBE was performed in 96%, 87%, 87% and 73% cases respectively [10]. Despite these preoperative investigations, IOE was performed in 40% patients with the diagnostic yield of 76% [10].
- **PJS** – It is characterized by presence of multiple hamartomatous polyps throughout the GI tract, mucocutaneous pigmentation and an increased risk of GI cancers. These polyps are predominantly located in the small and can lead to several problems including recurrent abdominal pain, GI bleed, intussusception, bowel obstruction and perforation. As per the recommended guidelines, polyps more than 1 cm should be excised to prevent future complications [13]. Previously, these patients required surgical excision with or without IOE. But with the availability of DAE, many of these polyps can be removed endoscopically (**Figure 3**). Nevertheless, surgery and IOE is required



**Figure 1.**  
*Computed tomography - a 53-year-old lady presented with anemia, weight loss and recurrent abdominal pain for one year. On computed tomography, she was found to have thickening in the mid segment of the ileum (arrow) with proximal dilated bowel loops containing feculent material (A: Axial section, B – Coronal section).*

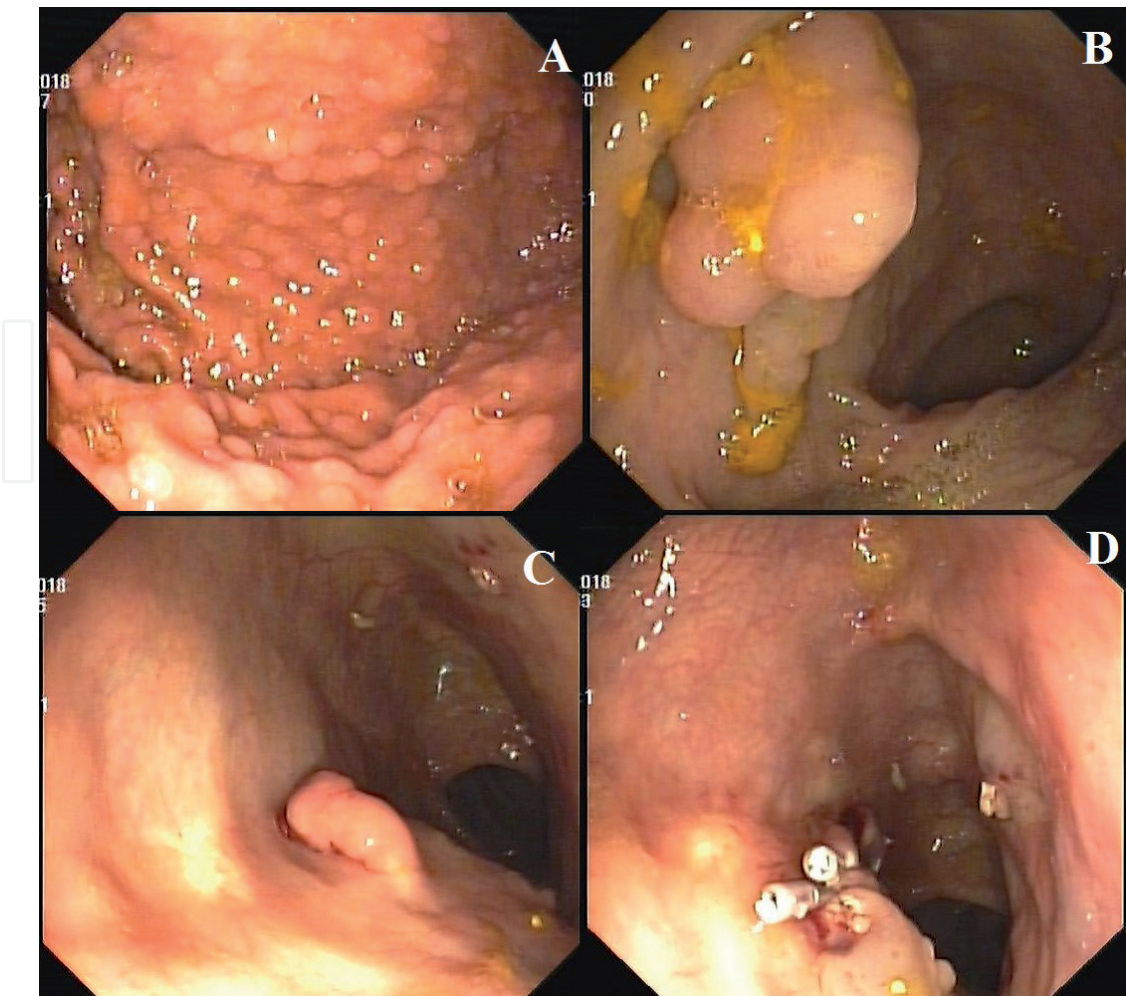


**Figure 2.**  
*Intraoperative enteroscopy via enterotomy of the patient with ileal thickening on computed tomography showing normal mucosal folds (A, B, C), a suspected vascular lesion (arrow, D), a small mucosal lesion (arrow, E) which was biopsied (F). No ileal stricture or significant mucosal disease was identified.*

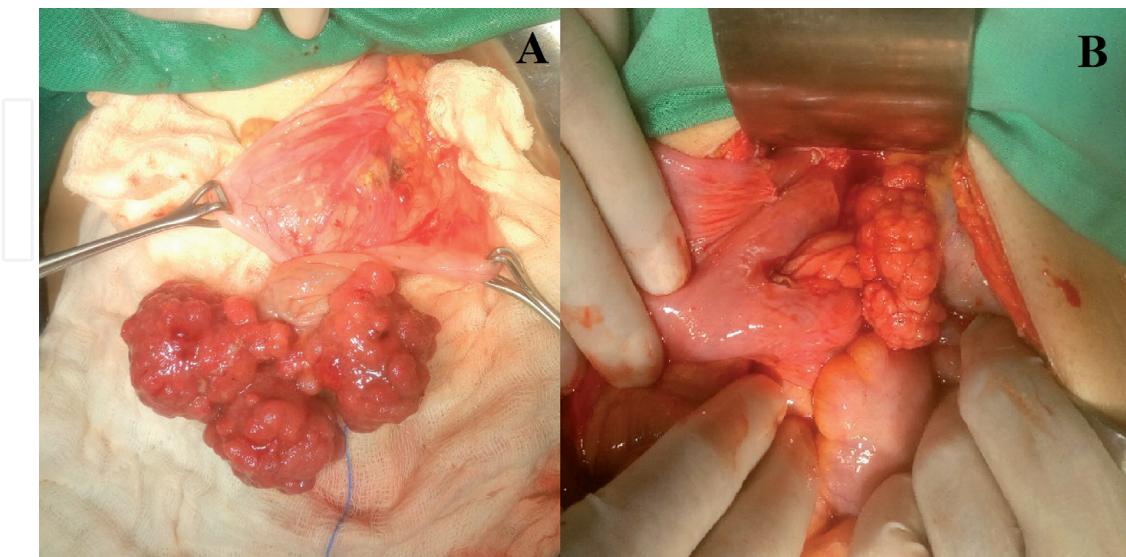
in many cases for complete exploration of small bowel and resection of large or malignant polyps (**Figure 4**). In a recent study of 27 patients with PJS, the success rate of enteroscopy was 76% [14]. IOE was required in 4 patients which improved the complete treatment rate to 92%. IOE has also been shown to facilitate polyp resection, reduce the number of laparotomies [6] and extensive bowel resection [15].

- Familial adenomatous polyposis (FAP) – It is an autosomal dominant disorder characterized by development of premalignant adenomatous polyps in the colon. Moreover, these patients are at the risk of development of duodenal polyposis, duodenal cancer, jejunal and ileal polyps [16]. Most of these can be visualized using conventional upper gastrointestinal endoscopy and colonoscopy. CE and DAE are useful for the visualization of jejunal and ileal polyps. However, in FAP patients with history of abdominal surgery such as pancreatoduodenectomy for duodenal cancer or total proctocolectomy for colorectal





**Figure 3.**  
*Peutz-Jeghers syndrome – The follow-up gastroscopy of the patient with Peutz-Jeghers syndrome one year after intraoperative enteroscopy and polyp excision showing multiple small polyps throughout the stomach (A). Few pedunculated polyps were present in the large bowel (B, C) which were excised endoscopically (D).*



**Figure 4.**  
*Peutz-Jeghers syndrome – A 29-year-man presented with recurrent abdominal pain. On evaluation, he was found to have multiple polyps throughout the small and large intestine causing intussusception. At surgery, intraoperative enteroscopy via oral and anal route was performed and small polyps amenable to endoscopic resection were excised. Two large polyps, one in the transverse colon (A) and another in the proximal jejunum (B) were marked by endoscopy and excised surgically.*

cancer, diagnostic and/or therapeutic DAE can be difficult. In such cases, IOE can be used to achieve complete clearance [16].

- Crohn's disease (CD) – It is an inflammatory bowel disease predominantly affecting the small intestine. The transmural inflammation leads to the development of deep ulcers causing GI bleeding and small bowel strictures causing intestinal obstruction. In presence of strictures, CE is contraindicated due to the risk of impaction. DAE also has its limitation in passing across the tight strictures making complete small bowel examination difficult. IOE helps in examining the mucosal side of the involved bowel segments to determine the disease activity. Previous studies involving CD patients have reported that IOE can identify new lesions not seen on preoperative examination [17].

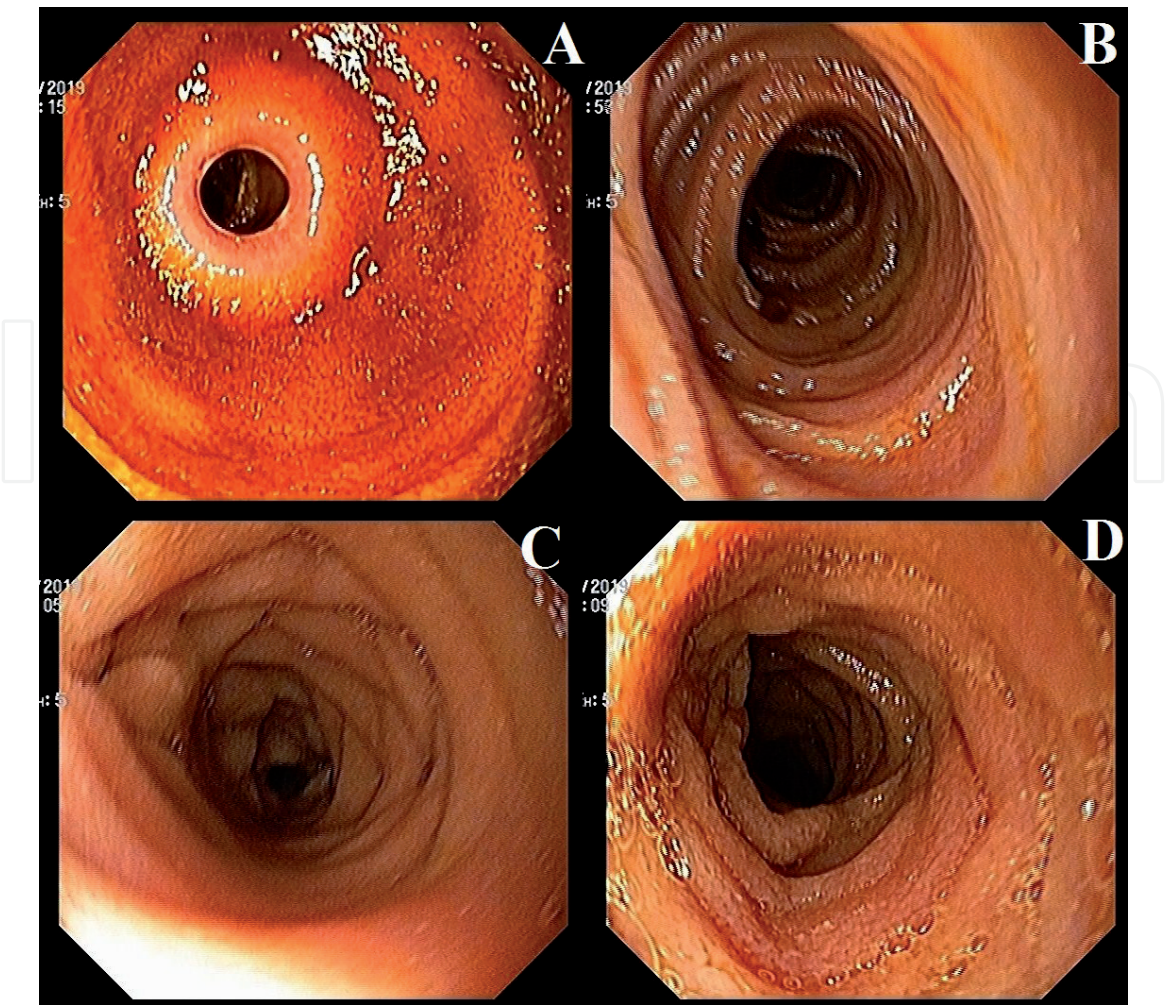
Patients not responding to medical therapy or those who develop persistent GI bleeding or intestinal obstruction require surgical intervention. At surgery, multiple segments of small bowel with skip areas are often involved. The extent and type of surgery in such cases is difficult to ascertain. IOE allows complete small bowel examination and helps in surgical planning. In such cases, surgical intervention is most often performed for tight strictures (<15 mm diameter), stricture with active ulcer and bleeding ulcer [18].

IOE is also useful in CD patients undergoing emergency surgery for intestinal obstruction or perforation without prior endoscopic examination. In such cases, complete small bowel evaluation along with ileocecal junction is important to prevent postoperative complications and avoid repeated surgeries.

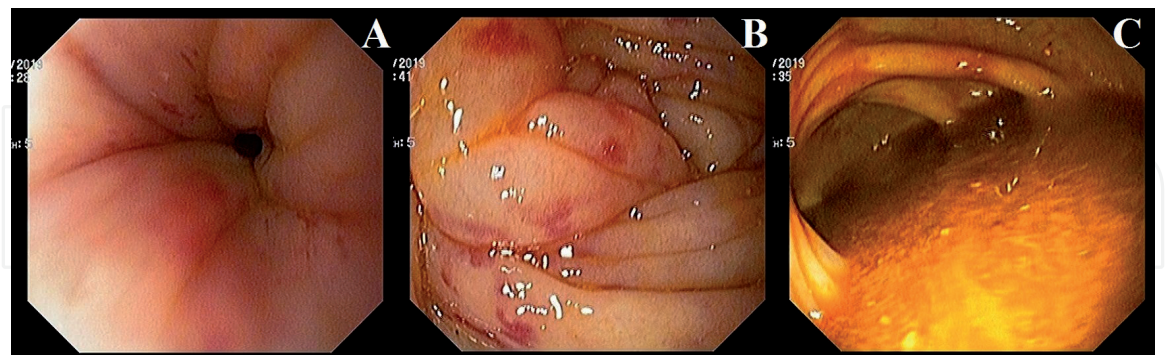
- Bowel obstruction or perforation – Sometimes, patients presenting with small bowel obstruction or perforation without prior endoscopic evaluation may require IOE for appropriate surgical treatment. One such situation is the presence of multiple strictures on preoperative CT. Similar to CD, patients with multiple strictures due to other causes such as tuberculosis requiring emergency surgery for intestinal obstruction or perforation can undergo IOE in the same sitting if feasible to allow complete small bowel examination and avoid multiple surgeries (**Figure 5**). Another clinical situation is difficulty in identification of the cause of bowel obstruction. In one of our previously reported cases, a patient of moderately severe acute gallstone pancreatitis developed colonic obstruction in the follow up [19]. On CT abdomen, there was a resolving peripancreatic collection surrounding the transverse colon with grossly dilated ascending colon and small bowel loops. In order to rule out mucosal disease, IOE via enterotomy route was performed (**Figure 6**). As there was no mucosal disease, side-to-side ileo-transverse colonic anastomosis was performed without colonic resection [19].
- Foreign body (FB) removal – Most of the cases of non-impacted FB ingestion can be managed conservatively. Sharp FB ingestion require endoscopic removal if feasible. Few cases with impacted FB in the small bowel not accessible to endoscopic removal or those who develop complications such as intestinal perforation require surgery.

Some cases with multiple FB ingestion located at different locations may require IOE to remove all the foreign bodies with minimum enterotomies. IOE can also help in such cases to confirm complete clearance during the operation [20].





**Figure 5.**  
*Intraoperative enteroscopy via enterotomy of a patient with multiple small bowel strictures on computed tomography showing a narrow stricture in the proximal ileum (A). Rest of the small bowel showed mild mucosal edema at few places with no obvious strictures (B, C, D).*



**Figure 6.**  
*Intraoperative enteroscopy via enterotomy of a patient with resolving acute pancreatitis and colonic obstruction showing mucosal edema at the site of obstruction (A, B) with grossly dilated colon loaded with feculent material (C).*

- Failure of DAE to identify or treat the lesion – Often, complete small bowel examination is not possible with DAE. The reasons for failure of DAE include previous laparotomies, bowel adhesions, anatomical variations, etc. [21]. In such cases, IOE is useful in achieving complete bowel evaluation and treatment if required in the same sitting.
- Abdominal surgery required for other reasons – In some situations such as CD with symptomatic gallstone disease or FAP with periampullary carcinoma, if

the patient is planned for abdominal surgery, then IOE can be performed in the same sitting instead of DAE.

- Identification of the site of disease during surgery – In the era of DAE, most of the small bowel lesions requiring surgical excision are marked with India ink. However, in some cases where the ink is not visible or cases where the mucosal lesions were detected on CE such as ectopic pancreatic tissue, arteriovenous fistula, and hemangioma, IOE is useful for intraoperative localization.
- Lack of DAE facility – DAE is available at most centers in developed countries. However, in low income countries or in limited resource setting, IOE is a safe and effective alternative to DAE. It allows diagnosis and treatment of the small bowel diseases in the same sitting.

### 3. Techniques

IOE is mainly performed via conventional laparotomy. However, it can be performed by mini-laparotomy [22, 23] or laparoscopy [24–27]. IOE can be performed by gastroscope, colonoscope, pediatric scope or balloon enteroscope depending upon the probable site of the lesions, the indication for IOE and the availability of the equipments. In rare circumstances, IOE can be performed using a laparoscope [28]. IOE can be conducted through oral route, anal route and through an enterotomy site (**Figure 7**). The choice of the preferred route for IOE depends upon the location of the lesion.

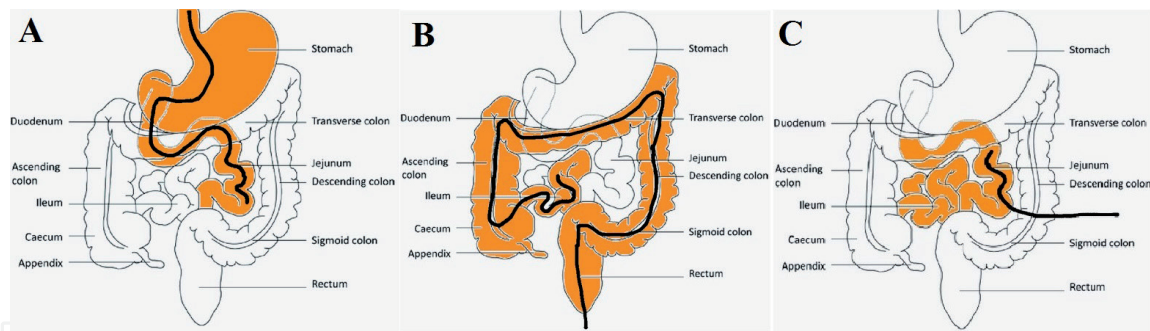
The patients are admitted before the procedure. All routine investigations including cardiorespiratory work up are done to rule out any contraindication for surgery. The day before the procedure the standard bowel preparation (the same as for colonoscopy) with either polyethylene glycol or sodium phosphate is given [29]. The patients are asked to fast for 6 hours before the surgery.

All the endoscopes and the accessories are sterilized before the procedure. The endoscopist has to scrub like any other member of the operating team. The part of the endoscope to be inserted in the operating field is covered with a plastic sleeve routinely used for laparoscopic procedures. This will help in maintaining the sterility of the procedure. The procedure is performed under general anesthesia.

#### 3.1 Intraoperative endoscopy via oral route

- Transoral endoscopy can be performed with the patient in supine or left lateral position [30]. Prior to the insertion of the endoscope, a nasogastric tube is placed to decompress the stomach. Subsequently, the nasogastric tube is removed and the gastroscope is inserted.
- Like the routine endoscopy, the gastroscope is passed in to the duodenum (**Figure 7A**). If the intraoperative endoscopy is pre-planned, then the endoscope can be passed as far as possible into the duodenum before the abdominal incision to take benefit of the tamponade effect of the abdominal wall.
- During the passage of the endoscope, a loop tends to form along the greater curvature of the stomach and the 'C' of the duodenum. Once, the endoscope has reached the jejunum, the assistant surgeon can place the right hand along the greater curvature of the stomach and the left hand over the second part of the duodenum to straighten the endoscope. This will help in going further deep in to the small bowel via the oral route.





**Figure 7.** Schematic presentation of different routes for intraoperative enteroscopy: (A) Transoral route, (B) transanal route and (C) enteroscopy via enterotomy.

- Deeper passage of the scope in to the jejunum is performed with the help of the operating team. Mobile small bowel and mesentery is necessary to facilitate smooth passage of the scope and avoid bowel injury. Hence, if adhesions are present then adhesiolysis should be performed by the operative team before initiating IOE.
- For the examination of the small bowel beyond the proximal jejunum, the operating surgeon straightens the bowel loops as the endoscopist gently pushes the endoscope in to the jejunum. Subsequently, about 40–50 cm of small bowel is telescoped on to the shaft of the endoscope by the operating surgeon.
- Advancement of the endoscope through the small bowel must be smooth, slow, gentle and under direct vision to avoid mucosal trauma by the endoscope and avoid excessive tension on the mesentery.
- The mucosa is thoroughly examined during the insertion and withdrawal of the endoscope. Any lesion if detected is biopsied or excised endoscopically using the standard techniques. Bleeding from the endoscopic excision site can be controlled by endoscopic techniques or transmural sutures by the operating team.
- If the lesion is big and requires surgical excision, then the site of the lesion must be marked with a simple suture by the operating team.
- In most cases, it is possible to examine the whole small bowel via oral route using the standard-length colonoscope. But if not possible, then the terminal ileum can be examined in a retrograde fashion via transanal route.
- The distal most point up to which the scope reaches in the small bowel is marked with a simple suture by the surgical team.
- Throughout the procedure, the operating room lights are dimmed so that the endoscopy team is able to clearly visualize the bowel mucosa and the location of the endoscope. The abnormal vascular lesions can be better identified by transillumination.
- During withdrawal, after inspecting the mucosa, the air is aspirated by the endoscopist and the surgeon occludes the intestinal lumen with his index and middle fingers to avoid re-insufflation.

- After completion of the endoscopy, the lesions at the marked sites are excised surgically by multiple enterotomies or segmental bowel resection depending upon the intraoperative findings.

### 3.2 IOE via anal route

- This is the least preferred route for IOE due to limited maneuverability.
- The procedure can be performed in lithotomy or left lateral position.
- The steps are similar to that of colonoscopy (**Figure 7B**). In case of difficulty in negotiating the scope across the colonic flexures, the operating surgeons can guide the scope.
- Small lesions can be excised or biopsied endoscopically while large lesions can be marked with simple suture for subsequent surgical excision.
- After reaching the ileocecal region, the surgeon slowly pushes the ileal loops over the scope for the mucosal examination. However, evaluation of the small bowel beyond terminal ileum via anal route is difficult.
- In such cases, if there is a large colonic lesion requiring surgical excision, a colotomy can be made near the site of resection and the colonoscope can be advanced through it to facilitate further small bowel examination.

### 3.3 IOE via enterotomy

- After appropriate adhesiolysis, whole of the small bowel is freed.
- A circular purse-string suture is taken at a suitable point (usually the mid portion) of the small intestine on the anti-mesenteric side [6]. A small enterotomy is made at the center of the purse string suture just sufficient enough to allow the passage of the endoscope.
- The endoscope is inserted through the enterotomy and the circular suture is tied around the scope over the bowel to prevent air leak during insufflation (**Figure 7C**).
- First, the proximal part of the small intestine is examined due to lower bacterial load.
- Enteroscopy should be performed slowly with gradual advancement of the scope and minimum insufflation to prevent bowel injury.
- Endoscopic biopsy or excision is performed for the visualized mucosa lesions as appropriate. If surgical excision is required, then the site of lesion is marked by the operating surgeon with a simple suture.
- During the inspection of the proximal half of the small bowel, the distal part is clamped and vice-versa to prevent over-inflation.
- The endoscopic views during IOE are different from the routine endoscopic picture due to transillumination by the operating lights in the theater. However, the operating lights can be dimmed if required as per the endoscopist's choice.

### **3.4 Insertion of port in bowel**

- In order to avoid contamination of the operative field, some authors have described the use of laparoscopic port.
- In this technique, a 12-mm or 15-mm bladeless laparoscopic port with or without balloon is inserted from the enterotomy site in to the bowel [31–34].
- The laparoscopic camera sleeve is fixed to the port with tape.
- The endoscope is passed through the camera sleeve and port in to the bowel for enteroscopy.
- This technique allows to maintain the sterility of the operative field.

### **3.5 Laparoscopic assisted panenteroscopy**

- In this technique, in order to avoid the laparotomy, the endoscope is passed through one of the 12- or 15-mm laparoscopic port [24–26].
- IOE can be performed via oral [25, 27, 34], anal [35] or enterotomy route [24, 26].
- The procedure for IOE via oral or anal route is same as described above except that the adhesiolysis and handling of the small bowel is performed laparoscopically. Additionally, the bowel insufflation has to be minimum to allow space for laparoscopic bowel manipulation [24].
- For IOE through enterotomy, a small jejunotomy is made and the endoscope is passed through it in to the bowel.
- Although the mobility of the scope is restricted compared to conventional IOE through laparotomy, it is possible to visualize the whole small intestine with careful manipulation of the small bowel loops.
- After the withdrawal of the endoscope, the enterotomy wound is sutured laparoscopically.
- However, this procedure is technically more demanding and time consuming. Both the laparoscopist and endoscopist need to be highly skilled and experienced.

### **3.6 Single incision laparoscopic (SILS) assisted enteroscopy**

- DAE is possible in most of the cases. However, in some cases, DAE may be difficult due to previous laparotomy, or inability to reduce the forming loops during DAE leading to incomplete bowel examination.
- In such cases, DAE can be performed under laparoscopic guidance. Laparoscopy can be undertaken by conventional 3-ports or SILS technique [21, 27].



- In SILS technique, a SILS port is inserted at the umbilicus. A 10-mm laparoscope and two 5-mm non-traumatic graspers are inserted through the SILS port. Laparoscopic adhesiolysis is performed before starting enteroscopy.
- Enteroscopy is performed using conventional flexible endoscope or DBE. Surgical manipulation of the bowel loops is done during enteroscopy if required.
- The visualized lesions can be excised endoscopically or laparoscopically depending upon the location and size of the lesions and the available expertise.
- In a recent study of 13 patients who underwent SILS enteroscopy, target pathology could be reached in all but one patient with PJS, in whom antegrade DBE failed to reach up to the target polyp and a small enterotomy was required to complete IOE and excise the polyp [21].

#### **4. Outcomes**

A review of 16 studies involving 468 patients by Voron T, et al. reported that the site of bleeding could be successfully identified in 371 patients (79.3%) [16]. The predominant lesions responsible for obscure GI bleed were vascular lesions (n = 227, 61%), benign ulcers (n = 70, 19%), tumors (n = 36, 10%) and diverticula (n = 15, 4%) [16]. The most common route of IOE was transoral followed by trans-enterotomy. A recent study by Manatsathit W, et al. also reported vascular lesions, ulcers and tumors to be the most common lesions detected on IOE [36].

The reported rates of diagnostic and therapeutic yield of IOE are 79.3% (58–100%) and 75.7% (48–94%), respectively [1–10, 16, 36]. The diagnostic yield for obscure GI bleeding after non-diagnostic abdominal imaging has been reported to be 91–100% and after non-diagnostic VCE/DAE varies from 14.2% to 66.7% [1, 6, 9, 36]. Traditionally, the treatment of the lesions detected during IOE were performed surgically. But, with the advancement in the endoscopic techniques, the lesions are being increasingly tackled endoscopically as far as possible and surgical treatment is performed for the rest of the lesions especially in condition like PJS.

#### **5. Complications**

IOE via enterotomy converts clean surgery in to clean-contaminated surgery which increases the risk of infective complications. Another problem of IOE is excessive bowel handling which increases the risk of postoperative ileus. The reported complication rates of IOE vary between 1 and 50% [16, 36, 37]. According to a combined data of 10 studies involving 309 patients, the overall morbidity rate was 16.8% which included surgical and medical morbidities [37]. The complications were mainly related to general anesthesia, laparotomy and bowel surgery required for bowel lesions and not solely related to IOE. Prolonged postoperative ileus was one of the predominant surgical morbidity. Other morbidities included bowel obstruction, wound infection, intrabdominal collections/abscess, intra-abdominal bleeding, chest infection and cardiorespiratory failure [18, 37]. The complications directly related to IOE include mucosal laceration, bowel wall hematoma, mesenteric hematoma or bleeding due to excessive handling during IOE and rarely, bowel perforation [38].

The overall mortality rate of IOE from the combined data of 14 studies including 419 patients was 5% [37]. The main causes of death were multiorgan failure, septic shock, diffuse intravascular coagulopathy and hemorrhagic shock [37].

An important issue in patients with obscure GI bleed after any investigation or treatment is the development of recurrent GI bleed. The reported incidence of recurrent GI bleed ranges from 13–52% in different series [9, 36, 37]. It is important to note that differentiation between iatrogenic mucosal trauma from mucosal vascular lesions by IOE is difficult [39]. Secondly, vascular lesions can be evanescent, hence early IOE or at time of bleeding can make the detection of these lesions possible [40]. Other reasons for rebleeding could be appearance of new lesions due to same or different disease, incomplete endoscopic treatment of the existing lesions such as angiodysplasia, etc.

## **6. Limitations**

IOE involves lot of small bowel handling and manipulation to allow smooth passage of the endoscopy across the bowel loops. In cases of dense adhesions with shortened mesentery, IOE can be difficult and increase the risk of bowel injury. Another situation where IOE is difficult is in the presence of massive GI bleeding as the lumen is completely filled with blood and examination of the bowel mucosa is not possible [7].

## **7. Conclusions**

With the increasing use of DAE, the need for IOE has reduced. However, it continues to be an extremely useful tool in patients with obscure GI bleed, multiple polyposis syndromes, multiple foreign bodies or bowel obstruction where DAE cannot be performed or has failed. Moreover, IOE has been found to reduce the need for repeated surgeries by allowing complete small bowel examination and treatment in the same sitting. Although IOE via laparotomy remains the gold standard, availability of advanced minimally invasive equipments have allowed IOE to be performed via multiport or single port laparoscopy.

## **Conflict of interest**

The authors have no conflict of interest to declare.

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