Intraoperative Enteroscopy: A Fast and Safe Technique for Localization and Treatment of Small Bowel Lesions

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Abstract

Objective: Intraoperative Enteroscopy (IOE) was first described in the late 1960s and is regarded as the gold standard for complete evaluation of the small bowel. However, with the advent of deep endoscopy and video capsule endoscopy, IOE has been used less frequently. Recently we published a large series demonstrating that IOE is a valuable tool for the final diagnosis and treatment of Small Intestinal Bleeding (SIB) and non-adhesive Obstructive Small Bowel Disease (OSBD) [1]. Existing literature lacks clear guidelines on the technique of IOE; therefore, we propose safe and effective methods to guide the surgeon's approach to IOE.

Methods and Procedures: As we recently described IOE is indicated in patients with SIB that is visualized but cannot be treated *via* endoscopy. For OSBD, IOE is indicated when computed tomography and/or initial enteroscopy are non-diagnostic and there is a suspicion for a resectable lesion (i.e. tumor or diverticulum), or when a pathologic lesion is identified but not amenable to endoscopic therapy. The procedure begins with standard diagnostic laparoscopy and complete evaluation of the small bowel. The evaluation includes visualizing a lesion or tattoos which may have been marked endoscopically beforehand. If no small bowel lesion is visualized, a six-centimeter supra-umbilical incision is made and an Alexis° wound protector is inserted for the purpose of IOE. The small bowel is eviscerated for complete visual inspection and manual palpation. If no lesion is palpated, IOE follows *via* an enterotomy made in proximity to the anticipated lesion or between proximally and distally marked ink tattoos. The enteroscope is secured with a purse string suture to prevent leakage of enteric contents. The small bowel mucosa is examined both anterograde and anterograde, with the gastroenterologist controlling the enteroscope and the surgeon simultaneously advancing the scope and telescoping the bowel extracorporally over it. Carbon dioxide is ideally used for insufflation. Definitive treatment depends on the type of lesion identified, with small bowel resection being the most common procedure. Post-operative management is patient and provider dependent. Generally, nasogastric tubes and urinary indwelling catheters are removed on postoperative day one and diet advanced as tolerated.

Conclusion: IOE is a safe, fast, and effective method for diagnosing and treating SIB and OSBD undiagnosed by conventional modalities. While the majority of the reports describing IOE have been published in Europe or Asia, we have proven that this technique is accurate and valuable in North America. Here we provide clear guidelines regarding the indications and appropriate technique by which to perform IOE in the United States.

Introduction

The small bowel represents an exceptional diagnostic and therapeutic challenge to the endoscopist, due to its length and tortuous anatomy [1-3]. Technical advances in recent decades have led to an evolution in small bowel imaging techniques, such as deep enteroscopy (Single-Balloon [SBE], Double-Balloon, [DBE], and Spiral Enteroscopy [SE]) and Video Capsule Endoscopy (VCE) [1,4,5]. Given the increasing availability of endoscopic technologies and operator proficiency in these techniques, the identification and treatment of pathologic lesions in the mid and distal small bowel have become more achievable [1,4,5].

However, despite these developments, upper and lower endoscopy fail to localize approximately 5% of cases of Gastrointestinal Bleeding (GIB), and VCE fails to diagnose approximately 20% of

Table 1: Indications and Contraindications for Intraoperative Enteroscopy.

Indications
Gastrointestinal bleeding
Bleeding lesions which are visualized but cannot be treated by standard esophagogastroduodenoscopy, colonoscopy or deep enteroscopy
Midgut bleeding when deep enteroscopy or VCE is not available
Bleeding refractory to endoscopic treatment
Small bowel obstruction with suspected resectable pathology;
Small bowel tumor
Intussusception
Small bowel diverticulum
Small bowel ulceration
Contraindications
Hemodynamic instability
Signs of peritonitis or acute abdomen

small bowel tumors [4-6]. Small bowel IOE therefore remains a valuable tool for the diagnosis and treatment of obscure sources of GIB and non-adhesive Obstructive Small Bowel Disease (OSBD) that has not been localized or cannot be treated by standard endoscopic techniques [1,4,7].

The intraoperative use of enteroscopy was first described in the late 1960s and since then, the majority of the published literature on the topic has consisted mainly of case reports or case series [8]. As a result, there continues to be substantial debate regarding when and how to perform IOE appropriately. The lack of consensus vis-a-vis proper indication and technique for IOE, in addition to the concern for the invasiveness and complications associated with laparoscopy and/or laparotomy required, have led to an overall reduction in its implementation [5,8,9]. Yet IOE is still regarded as the ultimate diagnostic procedure for complete evaluation of the small bowel [3,10,11].

We recently published a retrospective review of 112 adult patients who underwent open or laparoscopic abdominal surgery for suspected small bowel lesions in the jejunum or ileum at an academic medical center in Central Massachusetts over a 10-year period [1]. Thirty patients underwent IOE and diagnosis was successful by this procedure in 69% of patients initially presenting with SIB. Patients tolerated the procedure well with minimal complications [1]. Herein, we report a system that has been devised for fast, safe, and effective IOE for small bowel lesions.

Methods

Indications

Appropriate case selection remains critical for improved outcomes and maximal patient benefit from IOE. While most of the literature on IOE has focused on the adult population, IOE has been reported in pediatric patients as young as 8 months old [7,12]. IOE is indicated for patients with pre-operative diagnosis of GIB, with lesions suspected to be in the midgut, and not accessible by standard upper or lower endoscopy (Table 1). IOE may also be indicated in GIB when a midgut bleed is suspected and deep enteroscopy or VCE is unavailable, or have failed to reach the lesion. Furthermore, IOE is indicated when jejunal or ileal small bowel bleeding has been treated endoscopically, but is refractory to endoscopic therapy [1,4,5,6,13,14].

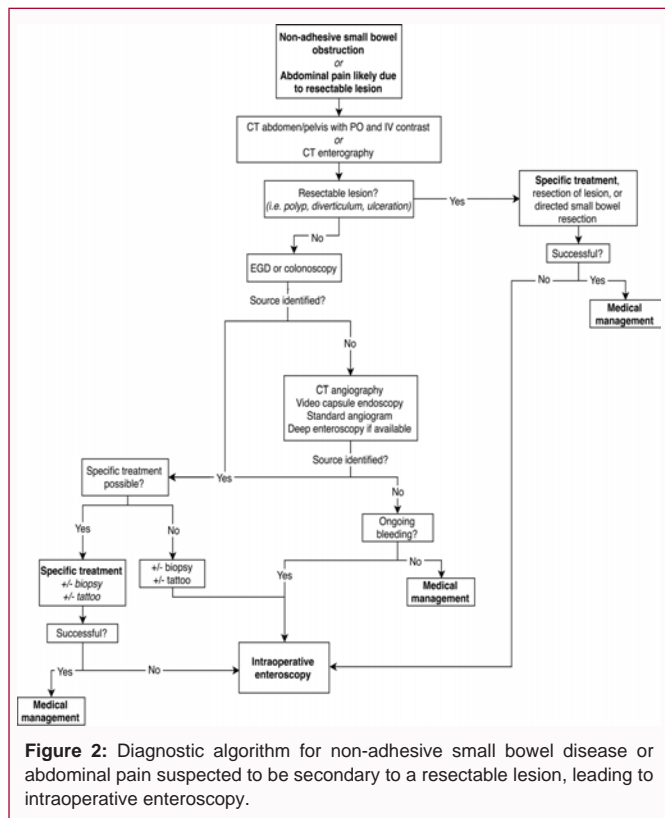In cases of non-adhesive Obstructive Small Bowel Disease
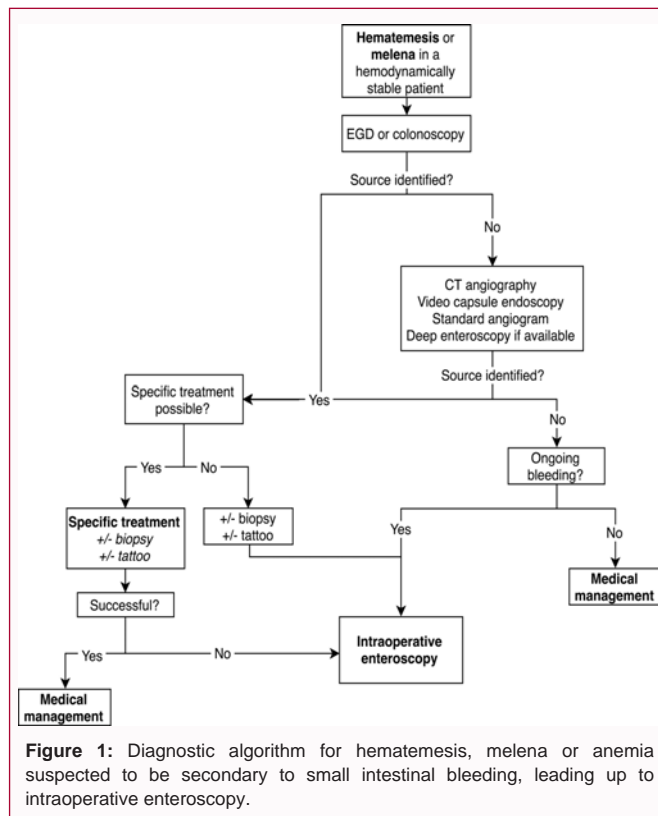
Figure 1: Diagnostic algorithm for hematemesis, melena or anemia suspected to be secondary to small intestinal bleeding, leading up to intraoperative enteroscopy.

(OSBD), IOE is indicated when Computed Tomography (CT) with or without enterography, or initial upper and lower endoscopies have been non-diagnostic, and there is suspicion for a small bowel tumor, intussusception, diverticulum, ulceration, or other resectable lesion in the jejunum or ileum (Table 1) [1]. In all cases, patients undergoing IOE should be hemodynamically stable and without any signs suggestive of peritonitis or an acute abdomen. Patients with comorbidities should be medically optimized and able to tolerate a pneumoperitoneum and standard diagnostic laparoscopy. Prior abdomino-pelvic radiation therapy is not a contraindication.

Pre-operative testing

For patients with hematemesis, melena, or anemia suspected to be secondary to GIB, Esophagoduodenoscopy (EGD) and colonoscopy should initially be performed. If no lesion is identified, VCE should then be pursued, followed by deep enteroscopy (SBE, DBE, or SE), if available. If during this workup the patient continues to have ongoing bleeding without identification of a source of bleeding, or if any of these procedures cannot be performed, the next step should be to proceed with IOE for definitive diagnosis and treatment of GIB (Figure 1).

For patients with symptoms of OSBD or abdominal pain, CT is the most effective initial modality for diagnosis [1]. CT of the abdomen and pelvis should be performed with oral and intravenous contrast. CT enterography may also be preferred. If no lesion is identified on preoperative imaging, EGD and colonoscopy are then performed. If a lesion is detected but definitive treatment is not possible, localization and tattooing can still be helpful in guiding surgical intervention, and should be performed. If no lesion is identified, VCE should be considered next to define the extent and length of the lesion and can also be used plan the location of the enterotomy, which will serve as the entry point for the enteroscope intraoperatively. Preoperative VCE

Figure 2: Diagnostic algorithm for non-adhesive small bowel disease or abdominal pain suspected to be secondary to a resectable lesion, leading to intraoperative enteroscopy.

Figure 3: Flow diagram describing step-by-step approach to intraoperative enteroscopy.

can also be useful in cases of OSBD as a retained capsule will serve as an indicator of the site of obstruction. Finally, if the aforementioned tests and procedures are non-diagnostic or cannot be performed, the patient should proceed with IOE (Figure 2).

Preoperative preparation

Preoperative bowel preparation is generally not needed. If there is concern for a distal lesion, two liters of polyethylene glycol can be given the day before surgery. The patient is brought to the operating room and routine pre-operative measures are taken, such as placement of sequential compression devices, subcutaneous injection of 5,000 units of prophylactic heparin, and administration of preoperative antibiotics (2 g of cefazolin or 3 g of cefazolin in patients' ≥ 120 kg, or 900 mg of clindamycin in penicillin allergic patients, plus 1 g of metronidazole). A urinary catheter may be inserted preoperatively based on physician preference and the procedure is performed under general anesthesia.

Operative description

Many variations in technique have been reported with respect to the intra-abdominal access for IOE. While a total laparoscopic approach to IOE has been reported [5,7], we have adopted a combined laparoscopic and open procedure. The procedure begins with the planning of a six centimeter (cm) supra-umbilical incision, through which the small bowel will be exteriorized and examined following the completion of the laparoscopic portion of the procedure. Depending on the findings from pre-operative imaging studies or endoscopies, planning of an infra-umbilical incision may be preferable, depending on the expected location of the small bowel lesion. In any case, the abdomen is entered under direct vision *via* the open Hassan technique through a small vertical incision made along the longer planned supra-umbilical or infra-umbilical marking. The abdomen may also be entered with the use of a Veress needle in
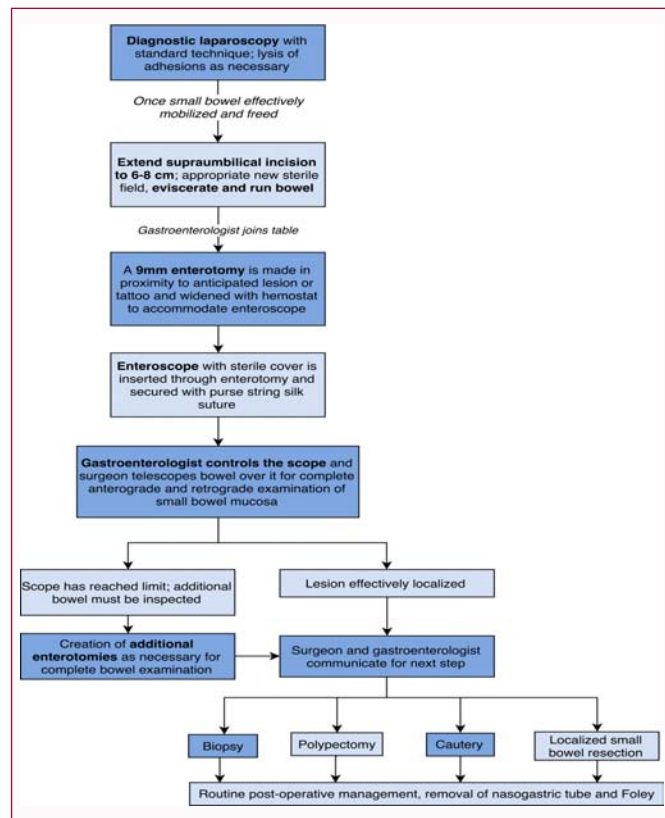
the left upper quadrant, approximately 3 cm below the costal margin, in the midclavicular line, at Palmer's point. Pneumoperitoneum is established with carbon dioxide (CO_2), a five millimeter (mm) 30-degree laparoscope is inserted, and the abdomen is inspected in standard fashion. Two additional five mm ports are placed in the left abdomen under direct visualization with the laparoscope. The patient is placed in modified reverse Trendelenburg position, with the right side of the patient tilted upward, to facilitate identification of the ileocecal valve. Laparoscopic lysis of adhesions is performed as needed to facilitate the complete examination of the small bowel. It is important that the small bowel is mobilized adequately to facilitate safe advancement of the enteroscope during the IOE [5]. The bowel is run from the ileocecal valve proximally to the ligament of Treitz using long fenestrated bowel graspers, advancing approximately ten cm at a time, while carefully and thoroughly examining both sides of the bowel for any previously placed tattoo marks or apparent abnormalities [15].

Once the entire small bowel has been examined laparoscopically and sufficient lysis of adhesions has been performed, the laparoscopic instruments and the umbilical trocar are removed. The previously made supra-umbilical or infra-umbilical incision is extended as was planned, to a length of approximately six cm, or a length that is adequate for evisceration and complete extracorporeal examination of the small bowel. Sterile blue towels are placed around the incision to accommodate a new sterile operative field. The small bowel is eviscerated and is run again completely, with careful inspection and palpation of its entire length. Particular attention should be directed to any previously tattooed lesions, or any suspicious segments of small bowel that were identified during laparoscopy, as well as the adjacent portions of the small bowel.

If a previously placed tattoo mark or an abnormal lesion is identified, a 2-0 silk purse-string suture is placed in proximity to this segment of small bowel, approximately three cm proximally or distally. If there are no tattoo marks and the bowel appears otherwise normal, then the purse string suture is placed at a location that best facilitates both proximal and distal endoscopic examination of the entire length of small bowel. A small enterotomy is made using electrocautery, approximately nine mm in diameter, at the center of the purse string suture. A hemostat is used to dilate the enterotomy until it is wide enough to accommodate the enteroscope.

The gastroenterologist is responsible for choosing the type of endoscope that will be used for the intraoperative enteroscopy. The use of pediatric and adult gastroscopes, colonoscopes, as well as deep enteroscopes has been reported. While scopes with larger diameters may be easier to control by the gastroenterologist, they may limit the length of bowel that can be examined. In contrast, smaller caliber scopes may allow for examination of more length of bowel in a single pass but may be more difficult to manipulate. A more flexible scope, such as a deep enteroscope, may allow the telescoping of the bowel through a smaller radius, and more bowels to be examined through the same enterotomy. The gastroscopeis the endoscope of choice in our practice and is the most commonly reported in the existing literature [11]. Regardless of the type of scope that is used, particular attention should be taken to avoid advancing the scope against resistance while examining the lumen of the small bowel, as this may result in tearing of the mesentery and subsequent venous bleeding. The surgeon and gastroenterologist should also consider the need for additional enterotomies, if examination of the entire length of the small bowel cannot be performed *via* a single entry point [5].

The gastroenterologist joins the surgical team scrubbed at the bedside and the selected enteroscope, enveloped in a sterile plastic sleeve, is introduced to into the operative field. While the enteroscope itself is not sterile, several modifications may be made to prevent and minimize contamination of the operative field, including; temporary suturing of the sterile laparoscopic plastic sheath to the borders of the enteroromy and the use of a 15 mm trocar to introduce the enteroscope into the enterotomy. We prefer to cover the enteroscope with a sterile plastic sheath and secure the scope with the previously placed purse string silk suture, to minimize spillage of enteric contents [5]. The purse string should be adjusted to permit movement of the scope but prevent spillage of luminal contents.

The bowel is insufflated with CO_2 to minimize residual intraluminal gas and bowel distension post-operatively, compared with conventional air-insufflation [16]. The enteroscope is advanced proximally or distally from the lesion. Complete inspection of the small bowel mucosa is performed with the advancement of the scope, and the bowel is also inspected for trans-illumination. It is important to examine the mucosa of the small bowel with both the initial advancement and withdrawal of the scope, in order to prevent misinterpretation of any iatrogenic trauma to the mucosa as a pathologic lesion.

The gastroenterologist controls the enteroscope while the surgeon telescopes the bowel over it. The surgeon may assist with advancement of the scope by manually pinching the bowel near the site the enterotomy, facilitating insufflation and optimal visualization of the mucosa with minimal trauma. Once a segment of small bowel is examined, the surgeon then pleats it over the enteroscope, and the next segment of small bowel is examined. Non-crushing, occluding clamps, may be placed at the ileocecal valve during anterograde endoscopy or at the duodeno-jejunal junction during retrograde endoscopy, to improve insufflation of the small bowel under examination [5,9]. Occasionally, the gastroenterologist may need to desufflate small amounts of CO_2 to assist with the advancement of the enteroscope. During this procedure, both the gastroenterologist and the surgeon should pay particular attention to avoid advancing the scope against resistance, as this may result in tearing of the mesentery and subsequent venous bleeding. The surgeon and gastroenterologist should also consider the need for additional enterotomies, if examination of the entire length of the small bowel cannot be performed *via* a single entry point [5]. These steps may be repeated sequentially both in anterograde and retrograde direction until the entire length of small bowel are examined. Prior to the withdrawal of the endoscope, the remaining CO_2 should be suctioned with simultaneous milking of the residual gas towards the scope.

If IOE is successful in localizing a suspicious lesion, the surgeon marks the site with a suture on the serosa of the small bowel segment prior to continuing with the enteroscopy. Once the endoscopic examination is complete, the decision is then made between the surgeon and the gastroenterologist whether the next most appropriate course of action is to biopsy, resect or cauterize the lesion, or rather to perform a directed small bowel resection and small bowel anastomosis. In our experience, the latter is the most commonly performed procedure and is accomplished with the use of standard gastrointestinal staplers for the resection and anastomosis.

In cases where a segmental small bowel resection and anastomosis is performed, a Nasogastric Tube (NGT) is routinely placed by the anesthesiologist during the procedure and placement is confirmed intraoperatively before proceeding to abdominal closure. If no lesion is identified, either by visual inspection, manual palpation or IOE examination, the scope will be removed and the surgeon will perform primary repair of the enterotomy. The small bowel is returned to the abdominal cavity, and standard closure of all previously made incisions will be performed. In our experience, the total operative time is between one to two hours.

Post-operative care

Post-operative management is both patient and provider dependent. If an NGT was placed intraoperatively, it can usually be removed on post-operative day one, providing that patient has not had significant nausea, emesis, and that the output from the NGT has been appropriately low. The patient can then resume a diet, initially with clear liquids, and can be advanced to regular diet as tolerated. As the diet is advanced, the patient's pain medications can also be transitioned from intravenous to oral route of administration. Pain is usually well controlled with acetaminophen, non-steroidal anti-inflammatories (ketorolac and ibuprofen), and minimal narcotic use. If an indwelling urinary catheter was placed pre-operatively or intraoperatively, it can usually also be removed routinely on post-operative day one.

Conclusion

Despite advancing endoscopic technologies and minimally invasive techniques for visualization of the small bowel, IOE should not be discarded from the surgeon's practice. This technique is particularly effective in diagnosing sources of occult GIB or non-adhesive small bowel obstruction in the jejunum or ileum, which cannot be diagnosed by conventional methods, including EGD,

colonoscopy, CT angiogram, small bowel enteroscopy or video capsule endoscopy. While the majority of existing reports describing IOE have been published in Europe or Asia, we have proven that this technique is accurate and valuable in North America. Having recently demonstrated that this technique, when performed by the general surgeon and gastroenterologist in tandem, at an academic medical center, is a safe, fast, and effective method for the diagnosis and treatment of midgut pathology, here we have detailed our approach to IOE [1]. We have included clear guidelines regarding the indications for IOE, step-by-step methods for the appropriate operative technique by which to perform IOE in the United States, along with a complete description of the routine pre-operative workup and post-operative care. Through the publication of this report, we hope to facilitate and simplify the adoption of our technique by practicing surgeons and gastroenterologists, and to improve the accessibility of IOE for patients with SIB and OSBD, who may largely benefit from this procedure.

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