Endoscopy

3

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Introduction

To look back at the history of endoscopy is to see the driving force and vision of individuals challenging the accepted knowledge of the time. Gastroenterologists are no different from most people and they do not embrace change easily. Early on, conventional wisdom resisted the need for gastroscopy let alone upper endoscopy including the duodenum at the technique's inception. Even the addition of biopsy capability to endoscopes was felt unnecessary by many in the beginning.

The evolution of enteroscopy has been largely the same and did not gain widespread acceptance until recently. Indeed, even the use of capsule endoscopy was a slow evolution. I fully realize that this chapter is not the most practical one in this volume, but a perspective on the development of small bowel imaging is still important. I have been involved in the field of enteroscopy since 1985 and this summary illustrates the work of many others in the field and their commitment to expanding the field of endoscopy despite criticism and resistance from colleagues. Swain referred to enteroscopists as "a tiny band of enthusiasts in showy endoscopy units" performing "an esoteric and rather terrifying procedure" [1]. He was correct, except for the part about "showy endoscopy units." Indeed, when you look through the references you will see a handful of names who carried the torch for a while. But enteroscopy has now come of age and is a rather routine examination revolutionized by capsule endoscopy and overtube assisted devices (e.g., double balloon, single balloon, and spiral enteroscopy). But that is not how it all started.

Flexible upper endoscopy with the ability to view the duodenum began with the development of the Hirschowitz ACMI 4990 fiberscope in October of 1960 [2]. Previous gastroscopes typically only viewed the esophagus and stomach and only rarely could be directed through the pylorus [3]. Previous biopsy forceps were passed alongside the gastroscope and thus directed biopsies were not possible and often the specimens were poor. Although flexible endoscopy was a huge advance over previous rigid and semirigid instruments, many doctors felt that the fiberscope had no future and, indeed, it was difficult to enter the duodenum. Norman Cohen reported 1,000 fiberscope exams in 1966, but stated it was unclear if the duodenum was entered in any examination [4]. Despite lack of acceptance and its own limitations based on size and maneuverability, many new instruments were developed and Olympus began producing a longer, 105 cm, model GIF in 1971. This endoscope became the workhorse of upper endoscopy until the development of video instruments in the 1990s.

Enteroscopy was initially a technology with little application, which slowed its acceptance.

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The small intestine was thought to be a rare site for any pathology and the ability to look at the most proximal and distal ends, during upper endoscopy and colonoscopy, was all that was needed in the evaluation of most patients. Some physicians doubted enteroscopy's clinical usefulness and thus expressed skepticism at the field's development. It was even stated that the development of sonde enteroscopy was unnecessary and most likely too expensive. Incredibly, similar opinions were voiced following the development of capsule endoscopy. But it is now clear that the power to peer into the small bowel changed medical practice and the technology has revolutionized the field.

This is especially true when dealing with a patient with unexplained gastrointestinal bleeding. Prior to the development of these technologies, patients with obscure bleeding were simply transfused. Small bowel cancers were diagnosed late and thus carried a very poor prognosis. Mortalities associated with obscure gastrointestinal bleeding were high. In 1980, Herbsman reported that survival of more than 6 months for adenocarcinoma of the small bowel was rare [5]. In 2006, there were 5,420 new cases of small bowel cancer reported along with 1,070 deaths [6]. It has been shown that early diagnosis improves survival. Early enteroscopy helped determine the etiology of bleeding in such cases and helped determine the most appropriate treatment algorithms. Of 71 patients treated for obscure gastrointestinal bleeding, Szold reported 19 patients with tumors detected early by enteroscopy [7]. In this series, 13 patients were long-term survivors and six died of metastatic disease. In a 2006 retrospective review of 144 patients with primary cancer of the small intestine, the overall 5-year survival was 57 % and the median survival was 52 months [8]. Not surprisingly, survival was best for early-stage tumors and those that could be completely resected. With the development of newer and more effective technologies, the relatively primitive and challenging techniques of rope-way and sonde enteroscopy have been abandoned and forgotten. In addition, there is less of a role for surgery guided by intraoperative enteroscopy. Yet it is important to recognize that they were instrumental in paving the way forward to where we are today.

Endoscopy of the small bowel was considered to be the last frontier of flexible endoscopy [9]. The usual diagnostic techniques applied to the small bowel were confounded by the small intestine's length and tortuosity, its free intraperitoneal location, and vigorous contractility. These characteristics, in turn, limited the diagnostic ability of barium small bowel studies and limited the identification of specific sites by special imaging techniques such as nuclear medicine scans and angiography. The yield of a barium small bowel series for diagnosing tumors of the small intestine remains quite low as does enteroclysis and even CT enterography.

There was clearly a need to improve the evaluation of the small bowel. Push enteroscopy was one of the early attempts to visualize the small bowel endoscopically. During push enteroscopy, an endoscope is pushed beyond the ligament of Treitz into the proximal jejunum. Push enteroscopy was termed deep upper endoscopy, extended upper endoscopy or simply enteroscopy. Though there is tremendous experience using orally passed colonoscopes as push enteroscopes, the first report of push enteroscopy was in 1973 using an instrument specifically designed for that purpose. Physicians and staff were concerned about the cleanliness of a colonoscope. Though we now accept that a clean instrument is a "clean" instrument, this was not true in the 1970s. Ogoshi reported in 1973 using an Olympus SIF-B to evaluate the proximal small bowel [10]. The instrument was 162 cm in length and had a 1 cm tip diameter. Fluoroscopy was used during intubation and it was estimated that 30 cm of jejunum were visualized. Several more reports followed using this instrument.

Push enteroscopy changed in 1983 when Parker and Agayoff reported that a colonoscope could be safely used instead of a designated instrument [11]. They gas sterilized the instrument prior to its use. This advancement made enteroscopy available to all endoscopists. The other major advance was the acceptance of push enteroscopy as the preferred method to obtain small bowel biopsies. The idea of visually

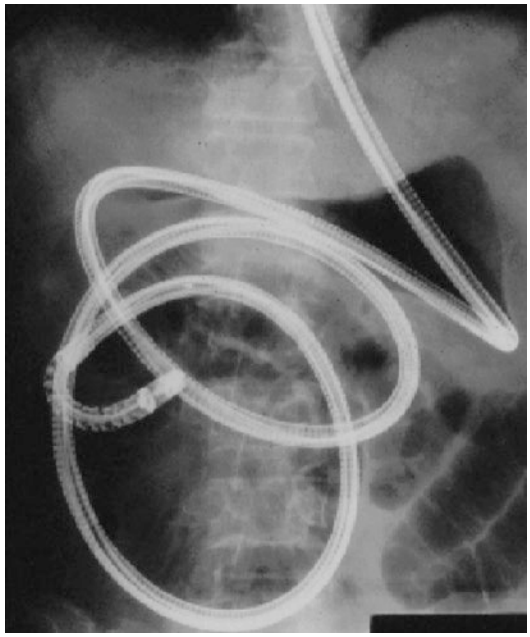

Fig. 3.1 X-ray of push enteroscopy using a 2 m long instrument

directed biopsies was attractive and Parker and Agayoff confirmed that the tissue samples obtained allowed for an adequate diagnosis when compared with suction tube biopsies—the standard at that time. Several studies confirmed the value of obtaining small bowel biopsies with an endoscope. The advantage of endoscopy over the Rubin tube was twofold. First, the endoscopist could visually inspect the mucosa and second, repeated biopsies were possible without removing the instrument.

Push enteroscopy took its next step when longer instruments were developed, measuring 200–225 cm in working length (Fig. 3.1). Stiffening overtubes were also created to allow even deeper small bowel intubation. By 1984, push enteroscopy had become mainstream. Several indications were proffered including evaluation of patients with obscure gastrointestinal bleeding and for the placement of jejunal feeding tubes. Messer, using a pediatric colonoscope, reported finding the bleeding site in 20 of 52 patients with obscure gastrointestinal bleeding [12]. Findings included angiodysplasias in 9 and small bowel tumors in 11. Foutch used an orally passed adult colonoscope and reported a yield of 38 % in 39 patients [13]. Chong reported finding a possible cause of bleeding in 64 % of 55 patients using the newer push enteroscope in combination with an overtube [14]. Push enteroscopy was therapeutic as well. Using bipolar cautery, Foutch was able to fulgurate angiodysplasias in 11 of 12 patients [13] and control of bleeding was attained in 8 of 11 treated patients. Askin and Lewis followed 55 patients who had cauterization of jejunal angiodysplasias for an average of 3 years [15]. This group required significantly fewer total transfusions when compared with their precauterization status as well as when compared to a cohort of patients who were not cauterized. Morris confirmed the effectiveness of cauterization at push enteroscopy in a group of 11 transfusion dependent patients [16].

It was 1982 when the first report demonstrated the use of enteroscopy in the diagnosis of a small bowel tumor. Shinya reported on the initial use of both sonde and push enteroscopy and described finding a duodenal adenocarcinoma and a jejunal hemangiolymphangioma [17]. The role of enteroscopy in the diagnosis of small bowel tumors has developed since that time. Often, small bowel tumors were diagnosed by other means and were confirmed by enteroscopy. Parker reported finding a large neurofibroma within the proximal jejunum [11]. Hashmi reported a 22-year-old woman presenting with melena [18]. The jejunal leiomyoma was diagnosed initially by angiography and was subsequently confirmed by push enteroscopy and enteroclysis. Shigematsu reported three patients with lymphangiomas of the small bowel diagnosed on small bowel series and subsequently confirmed on push enteroscopy [19]. Watatani reported, in 1989, a 73-year-old woman with nausea and vomiting in whom a small bowel series showed a distal duodenal lesion [20]. Push enteroscopy not only confirmed this lesion, but a biopsy was performed that revealed this to be adenocarcinoma preoperatively.

Push enteroscopy was also used to place jejunal feeding tubes. The initial idea was to carry a transgastric jejunal tube through a previous gastrostomy into the jejunum. Direct percutaneous jejunostomies were the next to be described.

Nasojejunal feeding tubes were also placed. The enteroscope was advanced to the jejunum, a guidewire was advanced through the instrument and the instrument was removed leaving the guidewire. The wire was transferred through the nasal passage and then using the Seldinger technique, the nasojejunal tube was positioned. This was used for feeding as well as to place catheters for enteroclysis and to obtain cholangiograms in patients after Roux-en-Y hepatic jejunostomies. Polypectomies were described as well as surveillance of patient with polyposis syndromes.

The rope-way method of enteroscopy was the oldest method to totally intubate the small intestine [21, 22]. It was in 1972, 4 years after the first description of colonoscopy, that Classen reported this procedure. The technique involved having a patient swallow a guide string and allowing it to pass through the rectum. The string was then exchanged for a somewhat stiffer Teflon tube over which an endoscope was passed. A complete endoscopic examination was obtained with this method. The instruments were fully therapeutic including cauterization and polypectomy. Unfortunately, the exam was painful due to tightening of the guide-tube and often-required general anesthesia. Due to patient discomfort, length of time necessary for string passage and development of better-tolerated techniques, the rope-way method was abandoned. Classen abandoned the technique shortly after his first report and described it as a "rigorous procedure" that was "traumatic to the patient." Video rope-way enteroscopes were also developed but these had the same limitations of the non-video versions [23].

Another development was endostomy, a procedure that involved creating an enterocutaneous fistula that could then allow a thin endoscope to intubate the small bowel [24]. Frimberger reported this technique in one patient. The fistulae were created using standard Ponsky gastrostomy techniques in the jejunum and in the cecum. After the tracts matured in 8–10 days, thin (4 mm diameter) prototype endoscopes were inserted through the jejunostomy and cecostomy to evaluate the intestine. Although innovative, this procedure was never accepted.

Fig. 3.2 Patient undergoing sonde enteroscopy while the instrument was carried into the small bowel by peristalsis

The last of the historical procedures is sonde enteroscopy. This was termed small bowel enteroscopy or long tube enteroscopy. The term sonde came from the French word for probe. In essence, it was an endoscopic Cantor tube, used for small bowel obstruction. A thin transnasal endoscope had a hood or balloon on its tip that allowed peristalsis to drag the instrument distally (Fig. 3.2). The endoscopic exam was performed during withdrawal of the scope. Development of sonde enteroscopy spanned nearly 13 years [25]. Prototype SSIF (sonde small intestinal fiberscope) I thru IV had narrow fields of vision (60°) and a large diameter (11 mm). Initially, a metal hood was placed at the instrument tip and used to induce distal passage. Subsequent prototypes had utilized a balloon at the tip that was inflated upon placement in the small bowel. Early enteroscopes were fitted with magnifying lenses to evaluate villi shape and were used in the diagnosis of

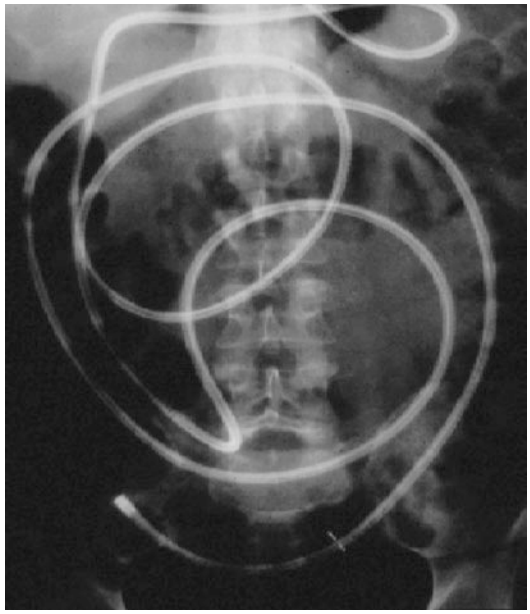

Fig. 3.3 X-ray of sonde enteroscopy with total small bowel intubation

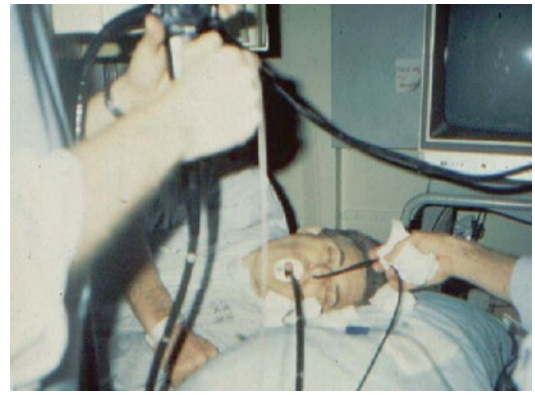

Fig. 3.4 Insertion of sonde enteroscope with orally passed colonoscope

tuberculosis and malabsorption states [26]. Attempts to introduce tip deflection capability in the fifth prototype made the instrument too stiff for distal intubation [27, 28]. Oral passage, which was required with these thick instruments, was associated with patient salivation, gagging, and considerable discomfort [29]. A thin, flexible, transnasal enteroscope was developed in 1986 [30] with a tip diameter of 5 mm and a length of 2,560 mm. The instrument's forward angle of view was initially 90°, but was subsequently increased to 120°. This instrument, in contrast to a push enteroscope, had no biopsy or therapeutic capability and no tip deflection. An attempt to add biopsy capability to this instrument in the tenth prototype was successful, but targeting the biopsy remained a problem since there was no tip deflection [31]. The major standard sonde enteroscope, the SIF-SW (small intestinal fiberscope—sonde, wide) did not have this biopsy channel, but remained transnasally passed with a fisheye lens (Fig. 3.3). Video technology was also applied to sonde enteroscopy. Dabezies reported on a video sonde enteroscope used in seven patients [32]. The instrument's tip measured 11 mm, due to the presence of the video chip, necessitating oral passage. The instrument did not use a balloon, and depth of intubation was limited.

The original technique to position a sonde enteroscope within the jejunum was to pass the instrument transnasally, lay the patient on their right side and follow the patient with sequential fluoroscopy. My first exposure to sonde enteroscopy was watching a videotape of Dr. Tada performing the examination on himself! A technique to rapidly place the enteroscope into the jejunum was developed to shorten the examination time. This rapid technique used a push enteroscope to grasp a suture affixed to the sonde instrument tip and actually "push" the scope into the jejunum (Fig. 3.4). The advantage of this technique was that it permitted total or near total small bowel intubation within 8 h and thus allowed the procedure to be performed on an ambulatory basis. The original technique averaged 24 h.

Sonde enteroscopy proved itself useful in the evaluation of the patient with presumed small intestinal bleeding. Initially, Lewis and Waye reported results of the technique in 60 patients with obscure gastrointestinal bleeding. In this report, a small bowel site of blood loss was detected in 33 % [33]. A later report by Lewis detailed results in 504 patients [34]. In patients with obscure gastrointestinal bleeding, combined push and sonde enteroscopy documented findings in 42 % of patients. Eighteen percent of the lesions were found in the region covered by push enteroscopy but distal to the area examined by

standard upper endoscopy. Twenty-six percent of the lesions were found in the remaining bowel examined by sonde enteroscopy. Vascular ectasias constituted 80 % of the findings overall and small bowel tumors accounted for 10 %. Several of the tumors discovered occurred in patients after a falsely negative enteroclysis [35]. Similar experience using sonde enteroscopy was reported by Barthel with a yield of 27.8 % in 18 patients [36], by Gostout with a yield of 26 % in 35 patients [37], and by Morris with a yield of 38 % in 65 patients [38].

Significantly, the nature of vascular lesions was better understood from these studies. Lewis reported an average age of 69 years in 102 patients with small intestinal angiodysplasias, without a sex predilection [33]. Angiodysplasias of the small bowel presented with either brisk or occult bleeding. Patients usually had only fecal occult blood test positivity or melena. Red or maroon blood per rectum was uncommon. Lewis reported that melena was the presenting sign in 64 % of 102 patients with bleeding small bowel angiodysplasias, while 36 % had occult blood in the stool. His findings also confirmed autopsy data by Meyer [39] who reviewed 218 angiodysplasias and found 2.3 % in the duodenum, 10.5 % in the jejunum, and 8.5 % in the ileum. Lewis also found that most patients had only a few vascular lesions that were countable, and all could be found within the same segment of small bowel. Diffuse lesions were much less common and were seen in less than 3 % of all patients with small bowel vascular lesions.

Despite numerous advances in sonde enteroscopy, it became clear that sonde enteroscopy had distinct disadvantages. The time required made it tedious for both patient and physician. Adhesions, strictures, and motility disturbances limited passive passage of the instrument. Even when complete small bowel intubation was achieved, total mucosal inspection was never complete. The lack of tip deflection and the inability to readvance the instrument once withdrawal had begun limited the mucosal view. Instruments also proved to be fragile and only one patient could be examined per day using the one instrument. Although this technology was a major advance and helped define obscure gastrointestinal bleeding, sonde enteroscopy was found to be inefficient. At its heyday there were 29 centers offering sonde enteroscopy, but by 1999 there were only 10, and today it is totally forgotten.

Fig. 3.5 The entire small bowel pleated onto a sterile colonoscope during intraoperative enteroscopy

Intraoperative enteroscopy remains the fallback procedure to allow total small bowel endoscopic examination when other procedures are unsuccessful. Colonoscopes are routinely employed for this examination, though a push enteroscope may also be used (Fig. 3.5). The instrument does not need to be sterile, since the recommended technique involves peroral intubation of the small intestine. The proximal jejunum is intubated prior to the performance of the laparotomy, since once the abdomen is open, it may be difficult to advance the instrument around the ligament of Treitz due to excessive, and unopposed, bowing of the endoscope shaft along the greater curvature of the stomach. With oral intubation of an adult colonoscope, the endotracheal tube cuff may need to be deflated to permit passage of the wide caliber endoscope. Once the colonoscope is placed within the proximal jejunum, laparotomy is performed. A non-crushing clamp is placed across the ileocecal valve to prevent distention of the colon with insufflated air. Colonic distention can lead to difficulties with subsequent abdominal closure.

The endoscopic exam is performed by having the surgeon grasp the endoscope tip and hold a short segment of bowel straight to allow endoscopic

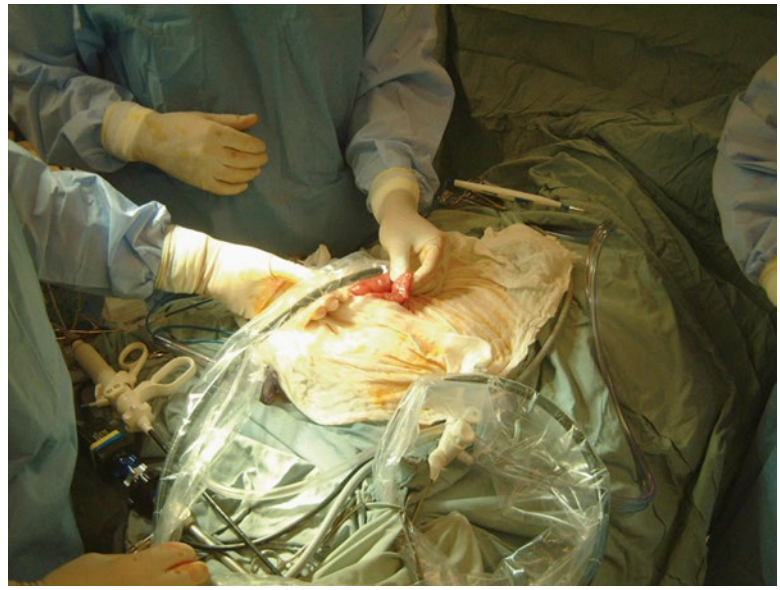

Fig. 3.6 Intraoperative enteroscopy with instrument placed in sterile sleeve and then advanced into the small bowel

inspection. The view is best seen by dimming the overhead lights, which also allows the surgeon to visualize the transilluminated bowel. Once examined both internally and externally, the small bowel is pleated onto the shaft of the endoscope and the next section of bowel is examined. Active bleeding within the small bowel may limit the effectiveness of this examination. Generally, examination is performed only during intubation since mucosal trauma occurs with the pleating and may be confused with the appearance of angioectasia on withdrawal [40]. Lesions identified with intraoperative enteroscopy are marked by the surgeon with a suture placed on the serosal surface of the small intestine. At the end of the examination, the endoscope is withdrawn and sites of resection are identified by the sutures. There are other techniques of intraoperative enteroscopy. This author performs an enterotomy through which an enteroscope covered by a sterile plastic sheath is placed (Fig. 3.6).

Intraoperative endoscopy has been used for several reasons. It is presently the endoscopic method most widely used in identifying small intestinal sites of bleeding (Fig. 3.7). This most typically involves a bleeding site identified on capsule endoscopy and not approachable by other endoscopic means. Intraoperative enteroscopy is also used in cases where surgical guidance is needed to limit small bowel resection. This is especially true in patients with hereditary hemorrhagic telangiectasia (HHT) syndrome where there are often diffuse lesions that are limited to the jejunum. The diffuse nature often limits enteroscopic management, and the surgeon needs to know where these lesions are located. Intraoperative enteroscopy is also used in patients with small bowel polyposis such as Peutz–Jeghers. Multiple polypectomies can be performed, and the specimens can be removed through enterotomy, limiting resection. Finally, intraoperative enteroscopy has

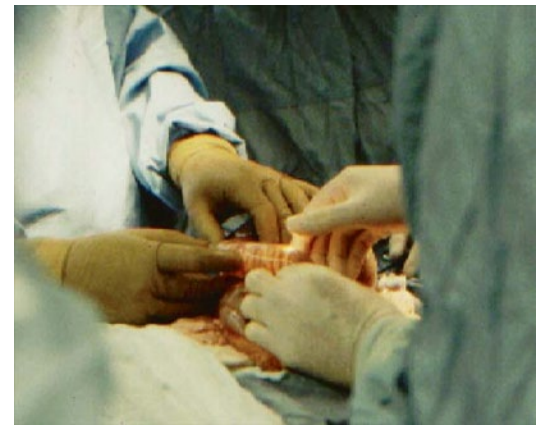

Fig. 3.7 Surgeons pleat the small bowel onto a colonoscope at intraoperative enteroscopy

been used to identify and guide resection of diaphragm disease of the small bowel caused by nonsteroidal anti-inflammatory drugs. These stenotic diaphragms of the small bowel are not palpable, and endoscopic guidance is often necessary intraoperatively.

Conclusion

Enteroscopy has changed dramatically since these early days, and no longer is the small bowel considered the rare site of pathology nor considered an area not accessible by endoscopic means. Yet the development of present-day capsule endoscopy or balloon or overtube assisted enteroscopy came from the steady work of individuals who did not accept the norm and pushed endoscopy to new vistas.

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