Capsule Endoscopy

by Sauyu Lin, Michael Shetzline, and Naurang Agrawal

The lack of a safe and reliable method for investigation of suspected small bowel diseases has fueled a tremendous amount of interest and growth in research for wireless capsule endoscopy. The wireless system consists of an ingestible 11 × 26 cm capsule, a sensor array to assist in localization of lesions, and a workstation to view the thousands of images of the small intestines. The procedure does not require administration of pro-motility agents or a bowel preparation, and is painless and safe. Data suggests that the diagnostic yield of capsule endoscopy for patients with obscure gastrointestinal bleeding and suspected Crohn’s disease is several folds higher than that of small bowel enteroscopy and other radiographic studies, with vascular lesions and ulcerations being the most common findings. Over 65,000 studies have been performed worldwide, and capsule endoscopy is quickly gaining acceptance as the gold standard for evaluation of the small bowel.

INTRODUCTION

Millions of people in the United States suffer from diseases leading to abnormalities affecting the small bowel (1); however, accurate imaging of this area has been difficult. Wireless capsule endoscopy is an innovative tool for the investigation of the small bowel and is rapidly gaining acceptance as the gold standard for its evaluation. Unlike the upper gastrointestinal tract or the colon, where upper endoscopy and colonoscopy has become standard of care for the diagnosis and treatment of intra-luminal disorders, routine diagnostic tools for the evaluation of the small bowel have been suboptimal and incomplete. The length of the small bowel (variable with average length of 22 feet or 6.7 meters), its free intra-peritoneal location with multiple overlying loops, and its active contractile pattern make conventional endoscopic and radiologic exams inadequate (2).

Contrast examination via small bowel follow through (SBFT) was previously felt to be the mainstay for the complete evaluation of the small intestines. Although large masses and ulcerations are clearly visualized during these examinations, flat lesions or limited mucosal disease may be missed. Studies have found the diagnostic yield of SBFT in patients with iron deficiency anemia and obscure gastrointestinal (GI) blood loss to be quite disappointing, ranging from zero to six percent (3–6). While several studies have suggested the superiority of small bowel enteroclysis over standard small bowel barium exams, overall diagnostic yields remain low, ranging from 10% to 25% (7–10).

Over the past decade, endoscopic examination of the small bowel (small bowel enteroscopy) has emerged as an effective alternative for the diagnosis and treatment of small bowel diseases. The three different types of small bowel enteroscopy include Sonde, intra-operative, and push enteroscopy. Sonde enteroscopy, using a three meter long endoscope that possesses limited tip deflection and no working channels, is labor and time intensive, and has largely been abandoned. Intra-operative enteroscopy, as the name implies, is the most invasive modality, and although reported success rates in patients with obscure GI
bleeding may be as high as 70%, it is used as a last resort, and only after other modalities have failed (11). Push enteroscopy is the most commonly used and universally accepted type of small bowel enteroscopy. The yield of push enteroscopy is reported to range from 13% to 78% (12–15), with the diagnostic utility highly dependent on the indication. Patients with obscure GI bleeding and abnormal imaging located in the distal duodenum or proximal jejunum have the highest diagnostic yields, while enteroscopy performed in patients with iron deficiency anemia, abdominal pain, and malabsorption are less helpful (15). Unfortunately, significant looping may occur in the stomach, and even with the use of the overtube—which may increase complications, has not resulted in a higher diagnostic yield, and is not routinely recommended—intubation of the small bowel is estimated to be only 80–120 cm beyond the Ligament of Trietz, leaving the majority of the small bowel unexamined (16). The lack of safe and reliable diagnostic modalities to completely examine the small intestines has fueled a tremendous growth in research and significant interest in the use of wireless endoscopy. The following review is based on studies currently available for capsule endoscopy. Because of the novelty of the procedure and the lack of a large number of published studies, multiple non-peer reviewed abstracts are referenced, and readers should take this into account.

HISTORY
The development of an ingestible capsule dates back to 1957. During that time, capsules were developed to measure gastrointestinal pH, temperature, and pressure (17–18). It was not until 37 years later, in January 1994, that Dr. Gavriel Iddan, a senior engineer for the electro-optical design section of the Israeli Ministry of Defense, and his team submitted the first of a number of patents for a wireless capsule used to directly image the small bowel (19). In search of investors for further development, Dr. Iddan collaborated with Dr. Gavriel Meron to form GIVEN (GastroIntestinal VideoEndoscopy) Imaging Ltd in 1998. During this same period, Dr. Paul Swain had similar ideas for wireless endoscopy and introduced this concept at the World Congresses of Gastroenterology in Los Angeles in 1994. Shortly thereafter in 1996, Dr. Swain and his team published the first live transmission of wireless endoscopy images from the stomach of a pig in abstract form, with the complete study published several years later (20–21). In his landmark study, Swain et al used a miniature charge-coupled device (CCD) camera, a microwave transmitter, and halogen and small torch bulbs wrapped in postmortem porcine gastric tissue to demonstrate feasibility of trans-gastric transmission to a color monitor. This prototype camera was subsequently placed in the mouth of a healthy volunteer and again verified the feasibility of this technique.

Dr. Swain joined GIVEN in 1998, and with the technological development of complementary metal oxide silicon (CMOS) image sensors, application-specific integrated circuit (ASIC) devices, and white-light-emitting diode (LED) illumination, working prototypes of the M2A (Mouth 2 Anus) capsule were produced in early 1999. Using an early version 11 x 30mm capsule with a six hour data recorder, the images of the first human study were published by Iddan, Meron, and Swain in 2000 (22).

THE GIVEN M2A SYSTEM
The GIVEN Diagnostic Imaging System (Given Imaging Ltd, Norcross, GA) is currently the only Food and Drug Administration (FDA)-approved wireless endoscopy system. It was approved by the FDA in August 2001, as an adjunctive tool for the evaluation of small intestinal diseases and disorders, and subsequently in July 2003, as a first line modality for evaluation of small bowel disorders. Currently, over 65,000 patients have undergone capsule endoscopy worldwide (1). The system consists of three main components: the M2A capsule, the sensor array antenna system with an attached data recorder, and the Reporting And Processing of Images and Data (RAPID) workstation to download and view the images (Figure 1). The average cost for the entire system is over $20,000 (Table 1).

The current M2A capsule is a one time use, disposable capsule weighing 3.7grams and measuring 11 x 26 mm in size (Figure 2). The capsule consists of eight main regions (Figure 3) and is composed of biocompatible material resistance to low gastric pH and (continued on page 16)
other digestive fluids. Patients fast overnight and take any necessary medications two hours prior to ingestion of the capsule. The capsule takes two images per second, and over 50,000 images are taken during an average eight-hour study. Images are shown in 1:8 magnifications with a 140 degree field of view and a 1 to 30 mm depth of view. Objects as small as 0.1 mm in size can be detected (23–24). To prevent obscuring the images, patients are encouraged to abstain from drinking fluids or consuming solid food until two and four hours, respectively, after ingestion of the capsule. The images obtained by the capsule are transmitted to the

Table 1
Cost
1. Single Capsule: $450.00
2. GIVEN Data Recorder Set with belt pack and batteries: $5,400.00
3. RAPID workstation and software: $14,500

Figure 1. The GIVEN M2A Capsule System: the M2A capsule, the sensory array and data recorder, and the RAPID workstation. Courtesy of GIVEN Imaging

Figure 2. The M2A capsule, shown here next to a coin. Courtesy of GIVEN Imaging

Figure 3. The eight main components of the M2A capsule. Courtesy of GIVEN Imaging

(continued from page 14)
Figure 4. The sensor array location guide. Courtesy of GIVEn Imaging

eight sensors attached to the abdomen and stored in the data recorder worn around the patient’s waist. The data recorder requires five nickel-metal 1.2 V batteries and houses a 305 gigabyte hard drive. The eight sensors are attached to the abdominal wall in a pre-determined pattern to better estimate capsule location by means of a triangulation method of localization (Figure 4) (6,23).

The contents of the data recorder are downloaded into the RAPID workstation. The download may take approximately two hours, although new hardware may be purchased to decrease the download time to 45 minutes. GIVEN propriety software must be used to view the images. Images may be viewed as one image (single view) or two images (multi-view) simultaneously. The adjustable rapid scan mode allows the viewer to view 1 to 25 images per second in the single view format and up to 40 images per second in multi-view. Landmarks such as the stomach, the duodenal bulb, the cecum, and any identified abnormalities may be marked by forming a thumbnail image. Thumbnails are short video clips of 50 images before and after a specifically identified image. Depending on the speed of the rapid scan, average time of interpretation may range from 30 to 90 minutes.

The capsule travels down the gastrointestinal tract by natural peristalsis. Transit times in patients vary significantly depending on the patient population and co-morbidities, but are generally slightly longer than in a healthy volunteer (25). Average gastric transit times in patients have been reported to be 47–69 minutes and average small bowel transit time 210–314 minutes. Failure to reach the cecum during the recording period occurs in 27% to 53% of patients (26–29). The capsule is then naturally excreted, usually within 24–48 hours.

**Localization**

Given the free intraperitoneal location of the small bowel and its constant peristalsis, accurate localization of pathology is difficult. Because wireless endoscopy is entirely diagnostic, surgical intervention may be necessary for specific findings. Thus accurate localization is vital in the consideration of all therapeutic options. The triangulation method of localization of the wireless capsule endoscope was initially introduced in 2001. The transmitted signal of the capsule is received by eight sensors attached to the patient’s abdomen. Its location is estimated by three sensors at any given time: the sensor in closest proximity to the capsule receives the strongest signal, and two adjacent sensors, which the capsule is located between, will receive signals of nearly equivalent strength. Using the strength of the signals and location of the sensors, an approximate location can be calculated (6). This triangulation method detected the capsule within 6 cm of its location in the abdomen 87% of the time in healthy volunteers who also received fluoroscopy (30). This method allows the lesion to be roughly placed into a specific abdominal quadrant, but does not indicate the actual distance down the small bowel. Patients with small bowel lesions requiring surgical intervention may still require the use of intra-operative enteroscopy to precisely localize the lesion.

*(continued on page 21)*
Suspected Blood Indicator
The suspected blood indicator (SBI) was recently developed for the GIVEN Imaging software. The SBI is a color detector designed to flag images containing the color red and marks these images for closer review. Using the gastroenterologist’s findings as the gold standard, a recent study found overall sensitivity, positive predictive value, and accuracy of the SBI for detecting small bowel lesions to be 25.7%, 90%, and 34.8%, respectively (31). If only actively bleeding lesions were evaluated, sensitivity, positive predictive value, and accuracy increased to 81.2%, 81.3%, and 83.3%, respectively. The SBI appears to be helpful in diagnosing actively bleeding lesions, but complete review by an experienced gastroenterologist is still needed to evaluate for other lesions.

INDICATIONS FOR USE
Currently, the M2A GIVEN capsule is FDA approved as a first line modality for evaluation of all suspected small bowel diseases. The most common indications for its use include patients with obscure GI bleeding and patients with suspected small bowel Crohn’s disease. The majority of studies have validated its usefulness in these patients. Other indications include evaluation of patients with hereditary polyposis syndrome, patients with an abnormality in the small bowel on radiographic study, and in patients with chronic abdominal pain. The utility of capsule endoscopy for the latter indication is less clear.

DIAGNOSTIC YIELD
The first trial comparing capsule endoscopy to push enteroscopy was performed in canines by Appleyard, et al in 2000 (32). Radiopaque, colored beads between 3–6 mm were sewn into the small bowel of nine dogs. Half were placed within 100cm of the pylorus, thus within reach of the push enteroscope. Push enteroscopy and wireless capsule endoscopy, delivered endoscopically into the duodenum, were performed. The sensitivity and specificity of push enteroscopy for detecting beads implanted within the entire small bowel was 37% and 97%, respectively, compared to 64% and 92% for capsule endoscopy. The higher sensitivity for capsule endoscopy was attributed to the larger number of beads found in the distal small bowel, out of the reach of the push enteroscope. The sensitivity of push enteroscopy for identifying beads within 100 cm of the pylorus was 94%, compared to 53% for capsule endoscopy. This disparity in favor of push was attributed to missed beads in the proximal duodenum by capsule during initial endoscopic delivery. This study suggested that push enteroscopy was useful in detecting lesions in the proximal small bowel, possibly superior to capsule endoscopy; however, its limited scope length prohibited diagnosis of lesions in the distal small bowel, lesions that were found by capsule endoscopy. Following this animal study, Appleyard reported the first use of capsule endoscopy for obscure GI bleeding in four patients (33). A diagnosis was made in three patients, two of whom subsequently received endoscopic treatment of vascular lesions. The capsule provided good views and no complications occurred.

The first clinical trial comparing capsule endoscopy and push enteroscopy in patients with obscure gastrointestinal bleeding was presented at Digestive Disease Week in May 2001 by Lewis and Swain (34). Twenty patients with obscure GI bleeding received both capsule and push enteroscopy. A site of bleeding was found in 55% of patients using capsule endoscopy compared to 30% for push enteroscopy (p = NS). Angioectasias were the most common finding (Figure 5a). Five of the bleeding sources were found distal to the push enteroscope. Four of the patients underwent surgical treatment based on capsule findings. None of the patients had difficulty swallowing the capsule and there were no complications. This study suggested safety and feasibility of capsule endoscopy and capsule-directed management in the diagnosis and treatment of small bowel lesions. A subsequent study by Ell, et al found the diagnostic yield of capsule endoscopy to be 66% compared to 28% for push enteroscopy in the same patient population (p < 0.001), strengthening the preliminary results published by Lewis and Swain (35). The most common findings were similar, and included vascular lesions, small bowel malignancies, and small bowel ulcerations (Figure 5b). Several additional papers and dozens of unpublished abstracts have further supported the use of capsule endoscopy in the evaluation of obscure GI bleeding (36–37).
Several studies have also suggested that capsule endoscopy may play a role in the evaluation of small bowel pathology in patients with known colitis or suspected Crohn’s disease. Ulcerations and strictures suggestive of small bowel involvement have been found in 40%–100% of patients, many of whom had a previous negative radiographic study (38–43). Fireman, et al prospectively evaluated 17 patients with suspected Crohn’s disease (43). Capsule endoscopy found evidence of Crohn’s disease (erosions, ulcers, and strictures) in 12/17 patients (71%). Ten of the 12 patients who received medical therapy had a good clinical response. More recently, Mow, et al retrospectively reviewed 50 patients with known or suspected Crohn’s disease, 22 of whom had a history of “isolated” colitis with no documented small bowel disease. Thirteen of the 22 patients subsequently had capsule findings consistent with Crohn’s disease. Over 80% of all patients with diagnostic findings symptomatically improved with Crohn’s-directed medical management. Although larger, prospective studies are needed, capsule endoscopy appears to be a useful tool in the evaluation of patients with suspected Crohn’s disease.

The use of capsule endoscopy for abdominal pain alone is less clear. There are no published articles to date defining its role for this indication, and multiple unpublished studies have found contradictory results. Several abstracts have found the diagnostic yields to be low at four to 11%, while another found the yield to be as high as 54% (44–46). This difference is likely due to the heterogeneity of this patient population, and further studies will be required to determine the utility of capsule endoscopy in these patients.

One recent abstract attempted to evaluate the clinical variables predictive of a positive study. Patients with high transfusion requirements, overt bleeding, NSAIDs or warfarin intake, and those receiving more than one upper endoscopy may be more likely to have a positive capsule study (47). In addition to vascular lesions and ulcerations, significant lesions such as malignancies, small bowel varices, tuberculosis, and even parasitic infections have also been identified by capsule endoscopy (48–50).

Capsule endoscopy may be superior to radiographic imaging in evaluating patients with obscure GI bleeding and suspected Crohn’s disease. The diagnostic yield of capsule endoscopy has been found to be several folds higher than SBFT, and a small case series suggested an advantage over enteroclysis (42-43,51). In three patients with extensive distal small bowel ulcerations diagnosed by capsule endoscopy, biphasic small bowel enteroclysis failed to show the lesions, even in unblinded radiologists (51). Recent abstracts have also shown a higher diagnostic yield for capsule endoscopy over small bowel magnetic resonance imaging (diagnostic yield 50% compared to 0%) and possible equivalence to that of intraoperative enteroscopy (52–54).

The use of capsule endoscopy and its diagnostic success in the small bowel should not replace a carefully performed upper endoscopic exam. The esophageal transit time of capsule endoscopy has been found to be less than ten seconds in a majority of patients, thus precluding a detailed evaluation. The Z-line is visible in only 29%, and esophageal transmission gaps occur in over 70% of all patients (55).

The utility of repeating a capsule study is currently unknown, and only one unpublished study has reported this use. In ten patients with persistent GI bleeding and previously poor capsule exam who received repeat capsule endoscopy, 50% of repeated studies revealed additional findings (56).
CONTRAINDICATIONS TO CAPSULE USE
Absolute contraindications for capsule use include gastrointestinal obstruction and gastrointestinal pseudo-obstruction/ileus. Relative contraindications include a history of a gastrointestinal motility disorder such as gastroparesis, a history of intestinal strictures or fistula, pregnancy, presence of cardiac pacemaker or defibrillator, a known history of multiple small bowel diverticula, a history of Zenker’s diverticulum, a history of extensive abdominal surgeries or radiation, and an active swallowing disorder or dysphagia.

PACEMAKER SAFETY
Although patients with a pacemaker and defibrillator are felt to have a relative contraindication to capsule endoscopy, current experience is that minimal, if any, interference occurs between the devices (57–58). In a recent abstract, five patients with cardiac pacemakers received a baseline electrocardiogram (EKG) and a pacemaker check prior to receiving and a holter monitor during capsule endoscopy (59). Occasional PAC’s and PVC’s were seen while one patient had a three-beat run of asymptomatic non-sustained ventricular tachycardia. No hemo-dynamically significant arrhythmias were observed. Pacemaker function was not altered and capsule images were not affected. General consensus is to perform an electrocardiogram while placing an activated capsule next to the pacemaker device. If no abnormalities occur, the procedure may be continued.

BOWEL PREPARATION
There is currently no recommendation for a bowel preparation in patients receiving a capsule study. The standard regimen is an overnight fast. No studies have shown superiority of a bowel preparation compared to fasting, and several unpublished abstracts have actually suggested that it may compromise a complete capsule exam by prolonging gastric emptying (25,60). Kim, et al found no significant difference in image quality in patients who received four-liter polyethylene glycol prep versus fasting (61). Stolpman, et al found that gastric transit time was three times slower in the phosphosoda group (p 0.014) compared to no preparation and only 2/9 studies reached the cecum (60). We currently do not use or recommend a bowel preparation in our institution.

PROMOTILITY AGENTS
A significant percentage of capsule studies do not reach the cecum during the recording period (26–29). The use of a pro-motility agent such as erythromycin has not been recommended for use during capsule endoscopy, and no published studies have been reported. Several abstracts have suggested that the use of erythromycin prior to and even during the study may lead to higher percentage of complete exams. Fireman, et al found that administration of a 200mg oral dose of erythromycin one hour prior to capsule ingestion decreased gastric emptying time by approximately 65%, and only 4% of cases failed to reach the colon compared to 21.4% in the control group (p 0.02) (62). The mean small bowel emptying time, however, did not change, suggesting that the administration of erythromycin may decrease failure rate, yet not compromise the diagnostic utility of the capsule in the small bowel. Kim, et al found similar results, with a decrease in failure rate from 25% to 18% (63). The utility of erythromycin during capsule endoscopy is not known, but several small abstracts are promising, and we are awaiting further studies to define its role.

ENDOSCOPIC ASSISTANCE
In rare instances, such as patients with esophageal narrowing or severe gastroparesis, endoscopic assistance is needed to insert the capsule into the small bowel. Authors have reported different techniques for insertion at several large, national meetings. Hollerbach, et al reported successful placement of the capsule by unsedated upper endoscopy using a polypectomy snare (64). Swain and Appleyard reported successful use of an overtube for insertion into the stomach and a hydraulic insertion device for placement into the small bowel (65). Endoscopic assistance was also reported in a pediatric patient unable to swallow the capsule using upper endoscopy, a Roth Net, and conscious sedation (66). These reports indicate feasibility of capsule endoscopy in this patient population. In our institution,
endoscopic assistance using a standard upper endoscope and a Roth Net has been used in multiple patients with severe gastroparesis with great success.

**REPLAY SPEED, MULTI-VIEWER, READER EXPERIENCE: DOES DIAGNOSTIC YIELD CHANGE?**

Capsule endoscopy studies include more than 50,000 images, and it may take an average of 30-90 minutes to review a complete study, depending on the number of frames read per second. The GIVEN Imaging software currently allows a reader to view images one video stream at a time, called single view (SV), or two video streams showing alternating images simultaneously, called multi-view (MV). Several recent abstracts evaluated the different methods of viewing, along with replay speed and the experience of the reader on the diagnostic yield. Davidson et al compared two groups of gastroenterologists with variable capsule reading experience reading embedded abnormalities using SV or MV at various frame speeds (67). Overall detection rates of lesions were higher in the MV when compared to the SV (p = NS). The more experienced readers (>180 capsule reads) detected a higher number of lesions than the less experienced readers (40 capsule reads), and increasing view speeds from 15 to 21 frames/second resulted in reduction of detected lesions in less experienced readers. Rowbotham found similar results, with detection rates falling from 32%, 47%, and 79% at 15 frames per second (fps) to 16%, 26%, and 50% at 21 fps in three groups of readers with variable experience, noting that the reader with >50 reads detected the largest percentage of lesions (68). Even at 15 fps, 21% of lesions were missed by the experienced reader. These studies suggest that inexperienced readers (<40 capsule reads) should be assisted by more experienced readers, and studies should be read in MV fashion at no faster than 15 fps to decrease the number of missed lesions.

**COMPLICATIONS**

The major complication of capsule endoscopy is capsule retention. This is reported in 0.1% to 3.5% of cases (57,69–71). The capsule is often retained in a region of strictureing or within a diverticulum. Fortunately, because of the size and shape of the capsule, a majority of patients are usually asymptomatic (57,69). However, symptomatic small bowel obstruction has been reported (72–73). Patients with a previous history of abdominal surgery do not seem to have a higher rate of capsule retention (73).

**ROLE IN PATIENT OUTCOME**

Although the general consensus is that capsule endoscopy has a higher diagnostic yield for small bowel lesions compared to other modalities, it is unclear whether the findings from capsule endoscopy and subsequent capsule directed management actually improves patient outcome. Currently, there are no published papers on the true benefits of capsule directed management. It is important to note that capsule endoscopy performed in healthy patients found abnormalities in nearly 23% of cases (74). This raises an interesting question. Are all abnormalities diagnosed by capsule endoscopy truly significant? In addition, up to 50% of patients suffering from vascular lesions may continue to bleed, even after surgical intervention (11). For capsule endoscopy to be clinically valuable, the higher diagnostic yield should translate into some patient or physician-perceived benefit, such as reduced transfusion requirements or resolution of bleeding altogether, less need for medical or surgical intervention, reduced medical cost or improved well being. Does capsule directed management truly have clinical value? Several recent abstracts have attempted to answer these questions, but the results have been contradictory. Several authors have suggested that capsule directed management has led to cessation of bleeding in 83%–100% of patients with obscure GI bleeding (75–77). Unfortunately, other authors have found the contrary, with clinical improvement reported to be as low as 24%–39% (78–80). For example, physicians at Georgetown hospital reported follow-up of 31 patients with obscure GI bleeding who had a positive study. Twenty-six percent (8/31) of patients had resolution of bleeding by capsule directed management; however, 20% were still transfusion dependent (80). Although some authorities have suggested that capsule endoscopy replace push enteroscopy and SBFT as the next diagnostic modality used after a negative EGD and colonoscopy in patients

(continued on page 31)
with obscure GI bleeding (81), there is still controversy about the true utility of capsule endoscopy. It is important to take into consideration that for patients with obscure GI bleeding who require multiple hospitalizations and requiring chronic transfusions, even a 10% benefit in outcome may be quite significant.

**PEDIATRIC PATIENTS**

Capsule endoscopy is currently FDA proved for adult use only. However, several abstracts have suggested similar utility in the pediatric population, with reports in patients as young as six-years-old (66,82–84). In a study of 30 patients, four with obscure GI bleeding, 20 with suspected Crohn’s disease, and six with polyposis syndrome, a yield of 63% was found. All capsule procedures were well tolerated, and although one capsule remained in the bowel for ten days, this was naturally excreted after administration of steroids. Furman, et al reported even more impressive results, with a diagnosis in 12/13 (92%) patients with suspected Crohn’s disease, obscure GI bleeding, and abdominal pain. Again, no complications occurred. These studies suggest that capsule endoscopy performed in pediatric patients may be safe, well tolerated, and useful.

**AREAS FOR FURTHER RESEARCH**

Unfortunately, the use of capsule endoscopy also has its drawbacks. Due to rapid transit, the evaluation of the esophagus is limited, and the sensitivity for upper GI tract lesions is poor (42,55). A lack of air insufflation, collected food, debris, and blood may lead to overlooked lesions in the small bowel. Patients with prolonged gastric transit times may have an incomplete exam, leading to missed lesions located in the distal small bowel. Lesions may also be missed when they are located on only one or two frames. Inexperienced readers may miss lesions or “overcall” normal lesions, possibly leading to unnecessary invasive testing. Currently, the capsule is entirely diagnostic. There is no method to control the movement of the capsule or perform biopsies and therapeutic interventions, although recent research is promising. Mosse and Swain, et al initially introduced the concept of electrostimulation in 2001. Using capsules with mounted electrodes, application of electrostimulation led to operator controlled movement in pigs (85). This technology was subsequently reported in a human volunteer at the 2003 Digestive Disease Week (86). Electro-stimulation was applied when the capsule had reached the small bowel, and propulsive and retropulsive movements were obtained without eliciting awareness of pain. Although only at an experimental level, the rapidity of technological advancement in capsule endoscopy suggests therapeutic capsule endoscopy may be within our grasp.

**Reference**

Capsule Endoscopy

A SPECIAL ARTICLE


34. Lewis BS, Swain P. Capsule endoscopy in the evaluation of patients with suspected small intestinal bleeding: results of a pilot study. Gastrointest Endosc, 2002;56:349-353.


Capsule Endoscopy


