How helpful is capsule endoscopy to surgeons?

Osman Ersoy, Bulent Sivri, Yusuf Bayraktar

Abstract
Capsule endoscopy is a new technology that, for the first time, allows complete, non-invasive endoscopic imaging of the small bowel. The efficacy of capsule endoscopy in the diagnosis of suspected small bowel diseases has been established. Important applications for surgeons include observations of obscure gastrointestinal bleeding and small bowel neoplasms.

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Key words: Capsule endoscopy; Surgery; Small bowel neoplasm; Obscure gastrointestinal bleeding; Angiodysplasia

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INTRODUCTION
The small intestine is the most difficult part of the gastrointestinal tract to evaluate due to its length and complex loops[3]. Capsule endoscopy (CE) has become the procedure of choice for diagnosis of occult mucosal disorders of the small intestine. First introduced at the 2000 Digestive Disease Week Conference in San Diego, California, the Given Imaging M2A capsule (Yoqneam, Israel) subsequently received approval from the US Food and Drug Administration (FDA) in mid-2001 for use in the United States. Over 10000 examinations have been performed worldwide and the complication rate has been established as only 0.75%[4]. The major indication for capsule endoscopy is the investigation of patients with obscure gastrointestinal bleeding (OGB), however, this novel diagnostic tool is also indicated for evaluation of early Crohn’s disease (CD), suspected small bowel tumor, surveillance of inherited polyposis syndromes, evaluation of abnormal small bowel imaging, evaluation of drug-induced small bowel injury, and for partially responsive celiac disease[5]. This paper reviews the current indications for CE and strategies to optimize utilization of this technology.

WHY IS IT DIFFICULT TO FIND THE SOURCE OF SMALL BOWEL LESIONS?

The small intestine begins at the pylorus and terminates at the ileocecal sphincter. The approximate length of the small intestine is about 3.7 m to 6.7 m. The major functions of the small intestine are digestion and absorption. Despite the fact that serious small bowel disease is uncommon, symptoms related to disordered function of the small bowel are quite common. Bleeding, weight loss, diarrhea and pain are among the most common reasons for patients to seek health care.

The small intestine is an uncommon source of gastrointestinal (GI) bleeding. Bleeding can manifest as iron deficiency anemia when occult and most commonly is dark red or purple when overt. Endoscopic exclusion of upper GI and colonic sources of bleeding is the single most important clue indicating a possible small bowel source. Causes of small bowel bleeding are as follows: angiodysplasia, Dieulafoy’s lesions, erosions/ulcers, Crohn’s disease, small bowel varices, tumors, NSAID enteropathy, radiation enteritis, small bowel diverticulosis, small bowel polyps, aortoenteric fistula, and Meckel’s diverticulum[6].

Small intestinal bleeding presents a unique clinical problem that differs from upper and lower GI bleeding in many aspects. Patients with small intestinal bleeding undergo more diagnostic procedures, require more blood transfusions, have longer hospitalizations, and have higher health care expenditures than patients with upper or lower GI bleeding[7]. Since the small intestine is the most difficult segment of the GI tract to examine with endoscopy because of its distinctive anatomy, length, and location, it is difficult to find the source of small bowel lesions.

WHAT TESTS ARE PERFORMED TO DETECT SMALL BOWEL LESIONS?

The diagnostic methods for use in potential small bowel diseases are radiologic (e.g. small-bowel follow through

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A PE is passed orally, after the surgeon completes the approach affords high diagnostic and therapeutic yields. Instead of diffuse disease is suspected, such a combined biopsy, treatment, or specific localization is possible. When a focal lesion operative candidates and had severe recurrent OGIB, which peristalsis has carried it. Visual diagnosis but not bleeding (both occult and overt) as reported by Berner SE affords good visualization of the small intestine. The source of bleeding was identified in 50 (76%) of 66 patients with GI bleeding[18].

Disadvantages of conventional endoscopic techniques, such as PE and colonoscopy with ileoscopy, include limited endoscopic examination of the small bowel and sedation requirements. A complete endoscopic evaluation was previously possible only with intraoperative endoscopy, but DBE and CE can now be used for complete examination of the small bowel. However, DBE requires sedation and this procedure is more difficult than other procedures.

WHAT IS CAPSULE ENDOSCOPY?

CE is a new technology that, for the first time, allows complete, non-invasive endoscopic imaging of the small bowel. The efficacy of CE in the diagnosis of suspected small bowel diseases has been established. Current applications include OGIB, inflammatory bowel disease (IBD), small bowel neoplasms (including polyposis syndrome), malabsorption disorders (including celiac disease), iatrogenic disease (nonsteroidal anti-inflammatory drug enteropathy and radiation enteritis), and clarification of abnormal small bowel imaging. There are many emerging indications, such as in pediatrics and suspected small bowel obstruction.

The technology, possibly due to advances in miniaturization, comprises an 11-26 mm disposable video capsule propelled by peristalsis. The capsule comprises a transparent optical dome, illumination from six light-emitting diodes, a camera, silver oxide batteries, transmitter and antennae. The field of view is 140 degrees and magnification is 1:8, which is capable of visualizing intestinal villi. The capsule takes two frames per second and the battery life is approximately 8 h, allowing the acquisition of > 55000 images[20]. Images are transmitted by radio frequency to an eight-point abdominal sensory array and recorded on a digital recorder worn on a belt. The images are downloaded to a computer and viewed with dedicated software, which allows for capsule localization. The suspected blood indicator is quite good at detecting active bleeding, but not for other lesions, and does not replace careful examination of the CE video. The capsule is swallowed after an overnight fast. There is no exploration and has dissected out any adhesions to free up the small bowel. With assistance by the surgeon, the entire small bowel can be accordioned or pleated over the enteroscope[18,24]. The small intestine is inspected on initial entry in 10-20 cm segments. Transillumination of the bowel is recommended to detect any potential bleeding sites. Mucosal trauma and contact bleeding will often result upon manipulation of the bowel over the endoscope, and these artifacts are often confused with definitive bleeding sites if the bowel is primarily examined upon withdrawal. Lesions should be marked with a suture by the surgeon for later resection. Occasionally, active bleeding or a column of blood is detected at laparotomy. The proximal margin should be marked. Intraluminally, the mucosa can be washed, blood can be suctioned with the enteroscope, and lesions may be localized, diagnosed, and/or coagulated.

DBE is an exciting new technique that allows complete visualization of the small intestine. The source of bleeding was identified in 50 (76%) of 66 patients with GI bleeding[18].

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Consensus currently on whether a small bowel preparation or prokinetics is required.

**HOW EFFECTIVE IS CAPSULE ENDOSCOPY AT DETECTING LESIONS OF THE SMALL BOWEL?**

**Obscure gastrointestinal bleeding**

Patients with GI hemorrhage of uncertain etiology are a diagnostic and therapeutic challenge. OGIB is defined as recurrent or persistent GI bleeding despite the absence of explanatory findings at initial upper and lower endoscopy. Estimates vary in the current prevalence of obscure bleeding among all cases of GI hemorrhage, but this was probably less than 5% before the introduction of CE. OGIB can be subclassified as either overt or occult bleeding, based on whether a patient has a history of gross GI bleeding symptoms, either melena or hematochezia. Overt bleeding can be manifested by recurrent iron deficiency anemia or positive fecal occult blood test results. Most often the site of hemorrhage is suspected to be the small bowel.[7,8] OGIB is the most common indication for CE. The diagnostic yield of CE for the suspected bleeding source in OGIB has been reported to be 38% to 93%.[37] In our study, this modality demonstrated the source or bleeding in 17 of the 23 patients (73.9%) with OGIB.[28] Using CE, the most commonly detected bleeding sources or clues in the small bowel included angiectasia, fresh blood, ulceration, tumor, and varices. Early studies seem to suggest that there is no significant difference in the diagnostic yield of CE in obscure-overt and occult-ocult bleeding.[39]

It has been shown that CE may be superior to PE,[30-39], small bowel series,[40,41] enteroclysis,[42] CT scan,[43] and DBE[44] in identifying small bowel lesions in OGIB. Studies comparing diagnostic yields of CE to PE in OGIB are summarized in Table 1.

| Studies               | n  | Diagnostic yield (%) |
|-----------------------|----|-----------------------|
| Ell et al, 2002[42]   | 32 | 83                    |
| Lewis et al, 2002[27] | 21 | 55                    |
| Lim et al, 2002[45]   | 20 | 70                    |
| Hartmann et al, 2003[46] | 33 | 76                    |
| Van Gossum et al, 2003[46] | 21 | 52                    |
| Saurin et al, 2003[46] | 58 | 69                    |
| Mylonaki et al, 2003[42] | 50 | 68                    |
| Ge et al, 2004[46]    | 36 | 65                    |
| Adler et al, 2004[46] | 20 | 70                    |
| Mata et al, 2004[46]  | 42 | 74                    |
| Leighton et al, 2006[46] | 20 | 50                    |

CE seemed to have a higher diagnostic yield than PE[30-39]. There is only one report in which PE had a higher diagnostic yield than CE.[40]. The diagnostic yield in CE was reported to be 52% to 83% compared to 19% to 61% in PE. Small-bowel pathologies were detected using CE in 28 (80%) of the 35 patients with OGIB, compared with 21 (60%) of the 35 patients using DBE[44].

Based on the algorithm proposed by the American Gastroenterological Association in 1999[46], we also suggest this algorithm for evaluation of OGIB in the era of CE.

**Small bowel tumors**

Tumors of the small bowel account for 5% of all GI tract tumors and 2% of cancers, although the accuracy of those estimates is uncertain because the current methodologies for examining the small bowel have proved inadequate. The diagnosis of small bowel tumors is frequently delayed, contributing to the poor prognosis for patients with malignant tumors.[40]. The diagnosis and localization of small bowel tumors has been a clinical challenge because of the inaccessibility of the small bowel to conventional diagnostic modalities. Enteroclysis has a much higher sensitivity than SBFT in detecting small bowel tumors.[31]. Although CT may be useful in diagnosing extraluminal and metastatic spread of small bowel malignancies, its role in detecting small intraluminal and mucosal lesions has been limited, with a diagnostic yield as low as 20%.[37].

Endoscopic evaluation of the small intestine has included SE, PE, intraoperative enteroscopy, and DBE. PE and SE in 545 patients with OGIB identified 31 (5.6%) small bowel tumors.[41] All of these procedures, however, have significant limitations, including degree of invasiveness, incomplete inspection of the small intestine, and prolonged procedure time.

de Mascarenhas-Saraiva and da Silva Araujo Lopes reported a 3.8% rate of primary tumors in the small intestine by CE.[40]. The accuracy of CE in diagnosing the small bowel tumors seemed to be superior to that of other methods. In a meta-analysis, 86 of 1349 pathologies (6.4%) that were identified at CE were intestinal neoplasms.[39]. Cobrin et al[46] reported that 9% of OGIB were caused by small bowel tumors. The types of tumor diagnosed by CE included 8 adenocarcinomas (1.4%), 10 carcinoids (1.8%), 4 GI stromal tumors (0.7%), 5 lymphomas (0.9%), 3 inflammatory polyps, 1 lymphangioma, 1 lymphangiectasia, 1 hemangioma, 1 hamartoma, and 1 tubular adenoma. Of the tumors diagnosed, 48% were malignant.

Our seven patients, in whom CE was performed for OGIB, underwent surgery after CE. Four of 7 patients had been reported previously.[39]. In three of 7 patients, the active bleeding (fresh blood or oozing blood) site was noted in the proximal small intestine. But the source of the bleeding in two patients was not clearly seen. The bleeding sources in all of them were identified in operation as angiodysplasia located in the proximal small intestine. In the patient who had a polyp with oozing blood, the source of bleeding was identified as follicular hyperplasia in the operation specimen (Figure 1). One patient had angiodysplasia noted without evidence of active bleeding. Because these lesions were thought to be the cause of the bleeding, angiodysplasia was confirmed by intraoperative...
enteroscopy during operation and was excluded with local resection (Figure 2A and B).

In one patient, a vegetative mass was demonstrated in the proximal jejunum, which was missed during an abdominal CT scan small bowel series. He was operated on and diagnosed as jejunal invasion of recurrent renal cell carcinoma (Figure 3A and B).

In one patient, in whom multiple ulcers were found in the proximal intestine by CE, histopathologic examination of the biopsy specimen taken during enteroscopy demonstrated adenocarcinoma. In one patient, in whom a single ulcer was found in the proximal intestine, histopathologic examination of the biopsy specimen taken during enteroscopy demonstrated GI stromal tumor.

Although specific localization of lesions within the small intestine by CE has been reported as problematic relative to surgery or other procedures, localizations of small bowel lesions in all our patients were found by CE to be nearly the same as localizations during surgery.

Standard terminology and further studies to define a reference standard for diagnosis and treatment outcomes with CE will be necessary and are recommended. Although the specificity and sensitivity of CE for OGIB have been defined, these have to be established for severe obscure bleeding.

CONCLUSION

Bleeding from small bowel lesions is a rare cause of GI blood loss. Cancers, IBD and infections account for 20%-25% of all small bowel bleeding, while arteriovenous malformations account for the vast majority of causes. Endoscopic therapies are limited to the parts of the bowel within their reach and are the only minimally invasive way to apply direct treatment to bleeding sources or to take biopsies. The development of the endoscopic capsule has changed the way in which gastroenterologists will approach GI bleeding originating from small bowel lesions. With further development and innovation, capsule endoscopy will improve the management of this condition. Particularly in malignant lesions of the small bowel and in bleeding, capsule endoscopy is very helpful for surgeons before operation.

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