Online Submissions: wjg.wjgnet.com
www.wjgnet.com
wjg@wjgnet.com

World J Gastroenterol 2007 July 21; 13(27): 3671-3676
World Journal of Gastroenterology ISSN 1007-9327
© 2007 *WJG*. All rights reserved.

TOPIC HIGHLIGHT

Yusuf Bayraktar, Professor, *Series Editor*

How helpful is capsule endoscopy to surgeons?

Osman Ersoy, Bulent Sivri, Yusuf Bayraktar

Osman Ersoy, The Department of Gastroenterology, Hacettepe University Faculty of Medicine, Ankara, Turkey
Bulent Sivri, The Department of Gastroenterology, Hacettepe University Faculty of Medicine, Ankara, Turkey
Yusuf Bayraktar, The Department of Gastroenterology, Hacettepe University Faculty of Medicine, Ankara, Turkey
Correspondence to: Yusuf Bayraktar, Hacettepe University, School of Medicine, Department of Gastroenterology, Ankara 06100, Turkey. bayrak@hacettepe.edu.tr
Telephone: +90-312-3051712 Fax: +90-312-4429429
Received: 2007-03-30 Accepted: 2007-04-28

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.

© 2007 *WJG*. All rights reserved.

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

Ersoy O, Sivri B, Bayraktar Y. How helpful is capsule endoscopy to surgeons? *World J Gastroenterol* 2007; 13(27): 3671-3676

http://www.wjgnet.com/1007-9327/13/3671.asp

INTRODUCTION

The small intestine is the most difficult part of the gastrointestinal tract to evaluate due to its length and complex loops[1]. 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 10 000 examinations have been performed worldwide and the complication rate has been established as only 0.75%[1]. 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[2]. 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[3].

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[4]. 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

[SBFT] and enteroclysis or computerized tomography [CT]), endoscopic (e.g., intraoperative endoscopy, sonde [SE], push [PE], or double balloon enteroscopy [DBE]), or surgical (with or without intraoperative endoscopy).

SBFT has a low diagnostic yield (0%-5.6%) in the investigation of obscure gastrointestinal bleeding (OGIB)[5]. The diagnostic yield of enteroclysis in OGIB has been reported to be 10% to 21%[5]. Although these radiographic studies may have high specificity for bleeding site localization and potential etiology, the sensitivity is too low to make them useful as a screening test. Yet, in the absence of tests with a higher sensitivity and specificity, these insensitive tests have been used for many years by clinicians who are trying to establish a diagnosis in patients with obscure GI hemorrhage. Although enteroclysis and SBFT might show a strictures, a large masses, a large polyps, tumors and deep ulcers, aphthous ulcer and vascular ectasia in small intestinal mucosa cannot be seen.

Angiography and technetium-99m labeled red blood cell scans are performed when bleeding is active and the patient is hemodynamically stable. Both procedures can detect bleeding rates of 0.5 to 1.0 mL/min. Diagnostic yields of nuclear scanning (sulfur colloid or red blood cells) and angiography are low, even with patients who have recurrent melena or hematochezia[6-11]. In selected patients with massive bleeding, angiography may be the best test because, in addition to demonstrating the bleeding site, it offers therapeutic capability.

PE involves peroral insertion of a long endoscope directly into the jejunum. PE has been reported to be safe and has a diagnostic yield of 38% to 75%[5,12]. However, the lesion is found within reach of the gastroscope in only 28% to 75% of the patients[13,14]. With enteroscopy, the most frequently seen lesions are angiectasias, especially in the elderly[13,15], and small bowel tumors, particularly in patients younger than 50 years[16].

SE affords good visualization of the small intestine[10,11,17]. SE is both sensitive and specific in patients with OGIB. Although SE is no longer commercially available and was never widely used, visualization of the ileum or beyond was possible in 77% of 545 patients with obscure bleeding (both occult and overt) as reported by Berner *et al*[11]. For esophagogastroduodenoscopy (EGD), with PE and SE results combined, 58% (322/553) had abnormal examinations, with 40% (219/553) beyond the reach of EGD[11]. GI angiomas were diagnosed in 34.5% of the combined enteroscopies (both PE and SE), small intestinal tumors in 5.6% of patients, and small-bowel ulcers and other lesions in 3%[11]. No bleeding sites were reported in 41.7% of all enteroscopies. The procedure time of SE is 6 to 8 h, and the diagnosis is feasible in ambulatory patients when the SE is withdrawn from the most distal locale to which peristalsis has carried it. Visual diagnosis but not biopsy, treatment, or specific localization is possible.

Before the development of CE, for patients who were operative candidates and had severe recurrent OGIB, laparotomy with intraoperative enteroscopy was strongly considered early in their course. When a focal lesion instead of diffuse disease is suspected, such a combined approach affords high diagnostic and therapeutic yields. A PE is passed orally, after the surgeon completes the 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[25].

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[26]. 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

Table 1 Studies comparing diagnostic yields of CE to PE in obscure GI bleeding

Studies	*n*	Diagnostic yield (%)	
		CE	PE
Ell *et al*, 2002[30]	32	83	30
Lewis *et al*, 2002[37]	21	55	30
Lim *et al*, 2002[33]	20	70	45
Hartmann *et al*, 2003[36]	33	76	21
Van Gossum *et al*, 2003[45]	21	52	61
Saurin *et al*, 2003[35]	58	69	38
Mylonaki *et al*, 2003[32]	50	68	32
Ge *et al*, 2004[38]	36	65	28
Adler *et al*, 2004[34]	20	70	25
Mata *et al*, 2004[31]	42	74	19
Leighton *et al*, 2006[39]	20	50	20

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 the patient has a history of gross GI bleeding symptoms, either melena or hematochezia. Occult bleeding can be manifested by recurrent iron deficiency anemia or positive fecal occult blood test results[6]. 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%[27]. 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 obscure-occult bleeding[29].

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.

The commonly missed small bowel lesions by SBFT compared with CE include angiectasia, bowel ulcer and erosion. Some investigators have proposed that SBFT only be performed in a population at high-risk for capsule impaction, such as patients with Crohn's disease or in young patients suspected of small bowel tumors.

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[45]. 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[6], 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[46]. 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 [11]. 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%[47].

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[11]. 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[48]. 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[49]. 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[28]. 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

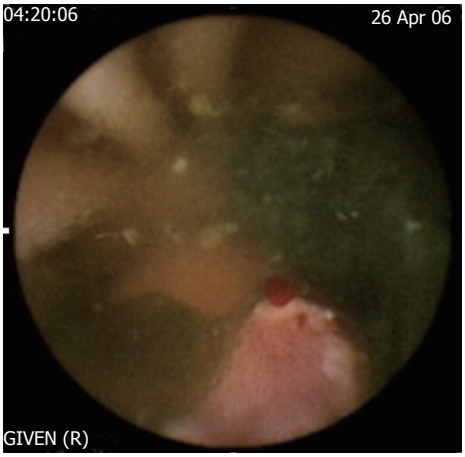

Figure 1 A polyp with oozing blood as a volcano was found by capsule endoscopy in the proximal small intestine.

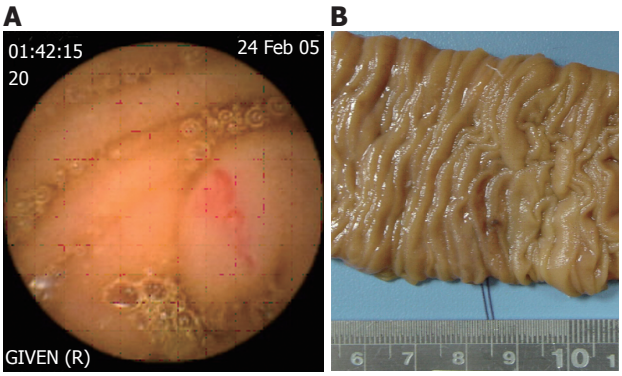

Figure 2 **A**: Angiodisplasia in proximal small intestine; **B**: Angiodisplasia was confirmed by intraoperative endoscopy in operation and was excluded with local resection.

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[40], 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.

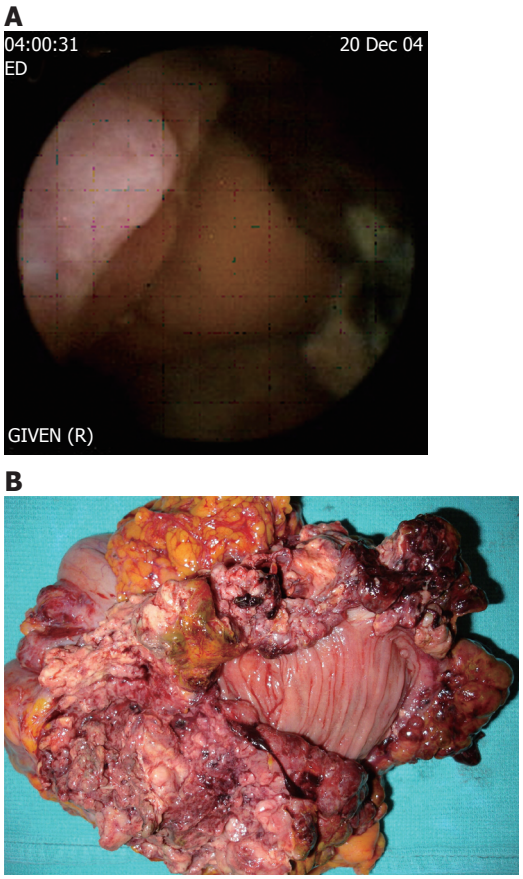

Figure 3 **A**: A vegetative mass was shown by CE; **B**: Histopathologic examination of the surgical specimen demonstrated invasion of recurrent renal cell carcinoma.

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.

REFERENCES

1 **Hara AK**, Leighton JA, Sharma VK, Heigh RI, Fleischer DE. Imaging of small bowel disease: comparison of capsule endoscopy, standard endoscopy, barium examination, and CT. *Radiographics* 2005; **25**: 697-711; discussion 711-718
2 **Eliakim AR**. Video capsule endoscopy of the small bowel (PillCam SB). *Curr Opin Gastroenterol* 2006; **22**: 124-127
3 **Carey EJ**, Fleischer DE. Investigation of the small bowel in

gastrointestinal bleeding--enteroscopy and capsule endoscopy. *Gastroenterol Clin North Am* 2005; **34**: 719-734
4 **Prakash C**, Zuckerman GR. Acute small bowel bleeding: a distinct entity with significantly different economic implications compared with GI bleeding from other locations. *Gastrointest Endosc* 2003; **58**: 330-335
5 **Zuckerman GR**, Prakash C, Askin MP, Lewis BS. AGA technical review on the evaluation and management of occult and obscure gastrointestinal bleeding. *Gastroenterology* 2000; **118**: 201-221
6 **American Gastroenterological Association medical position statement**: evaluation and management of occult and obscure gastrointestinal bleeding. *Gastroenterology* 2000; **118**: 197-201
7 **Kovacs TO**, Jensen DM. Upper or small bowel hemorrhage presenting as hematochezia. *Tech Gastrointest Endosc* 2001; **3**:206-215
8 **Jensen DM**. Endoscopic diagnosis and treatment of severe hematochezia. *Tech Gastrointest Endosc* 2001; **3**: 177-184
9 **Waye JD**. Enteroscopy. *Gastrointest Endosc* 1997; **46**: 247-256
10 **Lewis BS**. Small intestinal bleeding. *Gastroenterol Clin North Am* 2000; **29**: 67-95, vi
11 **Berner JS**, Mauer K, Lewis BS. Push and sonde enteroscopy for the diagnosis of obscure gastrointestinal bleeding. *Am J Gastroenterol* 1994; **89**: 2139-2142
12 **Van Gossum A**. Obscure digestive bleeding. *Best Pract Res Clin Gastroenterol* 2001; **15**: 155-174
13 **Zaman A**, Katon RM. Push enteroscopy for obscure gastrointestinal bleeding yields a high incidence of proximal lesions within reach of a standard endoscope. *Gastrointest Endosc* 1998; **47**: 372-376
14 **Hayat M**, Axon AT, O'Mahony S. Diagnostic yield and effect on clinical outcomes of push enteroscopy in suspected small-bowel bleeding. *Endoscopy* 2000; **32**: 369-372
15 **Descamps C**, Schmit A, Van Gossum A. "Missed" upper gastrointestinal tract lesions may explain "occult" bleeding. *Endoscopy* 1999; **31**: 452-455
16 **Lewis BS**, Kornbluth A, Waye JD. Small bowel tumours: yield of enteroscopy. *Gut* 1991; **32**: 763-765
17 **Gostout CJ**. Sonde enteroscopy. Technique, depth of insertion, and yield of lesions. *Gastrointest Endosc Clin N Am* 1996; **6**: 777-792
18 **Szold A**, Katz LB, Lewis BS. Surgical approach to occult gastrointestinal bleeding. *Am J Surg* 1992; **163**: 90-92; discussion 92-93
19 **Bowden TA**, Hooks VH, Mansberger AR. Intraoperative gastrointestinal endoscopy. *Ann Surg* 1980; **191**: 680-687
20 **Mathus-Vliegen EM**, Tytgat GN. Intraoperative endoscopy: technique, indications, and results. *Gastrointest Endosc* 1986; **32**: 381-384
21 **Ress AM**, Benacci JC, Sarr MG. Efficacy of intraoperative enteroscopy in diagnosis and prevention of recurrent, occult gastrointestinal bleeding. *Am J Surg* 1992; **163**: 94-98; discussion 98-99
22 **Cave DR**, Cooley JS. Intraoperative enteroscopy. Indications and techniques. *Gastrointest Endosc Clin N Am* 1996; **6**: 793-802
23 **Zaman A**, Sheppard B, Katon RM. Total peroral intraoperative enteroscopy for obscure GI bleeding using a dedicated push enteroscope: diagnostic yield and patient outcome. *Gastrointest Endosc* 1999; **50**: 506-510
24 **Douard R**, Wind P, Panis Y, Marteau P, Bouhnik Y, Cellier C, Cugnenc P, Valleur P. Intraoperative enteroscopy for diagnosis and management of unexplained gastrointestinal bleeding. *Am J Surg* 2000; **180**: 181-184
25 **Yamamoto H**, Kita H, Sunada K, Hayashi Y, Sato H, Yano T, Iwamoto M, Sekine Y, Miyata T, Kuno A, Ajibe H, Ido K, Sugano K. Clinical outcomes of double-balloon endoscopy for the diagnosis and treatment of small-intestinal diseases. *Clin Gastroenterol Hepatol* 2004; **2**: 1010-1016
26 **Ginsberg GG**, Barkun AN, Bosco JJ, Isenberg GA, Nguyen CC, Petersen BT, Silverman WB, Slivka A, Taitelbaum G. Wireless capsule endoscopy: August 2002. *Gastrointest Endosc* 2002; **56**: 621-624
27 **Tang SJ**, Haber GB. Capsule endoscopy in obscure gastrointestinal bleeding. *Gastrointest Endosc Clin N Am* 2004; **14**: 87-100
28 **Ersoy O**, Sivri B, Arslan S, Batman F, Bayraktar Y. How much helpful is the capsule endoscopy for the diagnosis of small bowel lesions? *World J Gastroenterol* 2006; **12**: 3906-3910
29 **Tang SJ**, Zanati S, Dubcenco E, Christodoulou D, Cirocco M, Kandel G, Kortan P, Haber GB, Marcon NE. Capsule endoscopy regional transit abnormality: a sign of underlying small bowel pathology. *Gastrointest Endosc* 2003; **58**: 598-602
30 **Ell C**, Remke S, May A, Helou L, Henrich R, Mayer G. The first prospective controlled trial comparing wireless capsule endoscopy with push enteroscopy in chronic gastrointestinal bleeding. *Endoscopy* 2002; **34**: 685-689
31 **Mata A**, Bordas JM, Feu F, Ginés A, Pellisé M, Fernández-Esparrach G, Balaguer F, Piqué JM, Llach J. Wireless capsule endoscopy in patients with obscure gastrointestinal bleeding: a comparative study with push enteroscopy. *Aliment Pharmacol Ther* 2004; **20**: 189-194
32 **Mylonaki M**, Fritscher-Ravens A, Swain P. Wireless capsule endoscopy: a comparison with push enteroscopy in patients with gastroscopy and colonoscopy negative gastrointestinal bleeding. *Gut* 2003; **52**: 1122-1126
33 **Lim RM**, O'Loughlin CJ, Barkin JS. Comparison of wireless capsule endoscopy (M2A) with push enteroscopy in the evaluation of obscure gastrointestinal bleeding. *Am J Gastroenterol* 2002; **97**: S-31. Not available
34 **Adler DG**, Knipschield M, Gostout C. A prospective comparison of capsule endoscopy and push enteroscopy in patients with GI bleeding of obscure origin. *Gastrointest Endosc* 2004; **59**: 492-498
35 **Saurin JC**, Delvaux M, Gaudin JL, Fassler I, Villarejo J, Vahedi K, Bitoun A, Canard JM, Souquet JC, Ponchon T, Florent C, Gay G. Diagnostic value of endoscopic capsule in patients with obscure digestive bleeding: blinded comparison with video push-enteroscopy. *Endoscopy* 2003; **35**: 576-584
36 **Hartmann D**, Schilling D, Bolz G, Hahne M, Jakobs R, Siegel E, Weickert U, Adamek HE, Riemann JF. Capsule endoscopy versus push enteroscopy in patients with occult gastrointestinal bleeding. *Z Gastroenterol* 2003; **41**: 377-382
37 **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
38 **Ge ZZ**, Hu YB, Xiao SD. Capsule endoscopy and push enteroscopy in the diagnosis of obscure gastrointestinal bleeding. *Chin Med J* (Engl) 2004; **117**: 1045-1049
39 **Leighton JA**, Sharma VK, Hentz JG, Musil D, Malikowski MJ, McWane TL, Fleischer DE. Capsule endoscopy versus push enteroscopy for evaluation of obscure gastrointestinal bleeding with 1-year outcomes. *Dig Dis Sci* 2006; **51**: 891-899
40 **Liangpunsakul S**, Maglinte DD, Rex DK. Comparison of wireless capsule endoscopy and conventional radiologic methods in the diagnosis of small bowel disease. *Gastrointest Endosc Clin N Am* 2004; **14**: 43-50
41 **Costamagna G**, Shah SK, Riccioni ME, Foschia F, Mutignani M, Perri V, Vecchioli A, Brizi MG, Picciocchi A, Marano P. A prospective trial comparing small bowel radiographs and video capsule endoscopy for suspected small bowel disease. *Gastroenterology* 2002; **123**: 999-1005
42 **Liangpunsakul S**, Chadalawada V, Rex DK, Maglinte D, Lappas J. Wireless capsule endoscopy detects small bowel ulcers in patients with normal results from state of the art enteroclysis. *Am J Gastroenterol* 2003; **98**: 1295-1298
43 **Eliakim R**, Fischer D, Suissa A, Yassin K, Katz D, Guttman N, Migdal M. Wireless capsule video endoscopy is a superior diagnostic tool in comparison to barium follow-through and computerized tomography in patients with suspected Crohn's disease. *Eur J Gastroenterol Hepatol* 2003; **15**: 363-367
44 **Hadithi M**, Heine GD, Jacobs MA, van Bodegraven AA, Mulder CJ. A prospective study comparing video capsule endoscopy with double-balloon enteroscopy in patients with obscure gastrointestinal bleeding. *Am J Gastroenterol* 2006; **101**: 52-57
45 **Van Gossum A**, Hittelet A, Schmit A, Francois E, Devière J. A prospective comparative study of push and wireless-capsule

enteroscopy in patients with obscure digestive bleeding. *Acta Gastroenterol Belg* 2003; **66**: 199-205
46 **Cobrin GM**, Pittman RH, Lewis BS. Increased diagnostic yield of small bowel tumors with capsule endoscopy. *Cancer* 2006; **107**: 22-27
47 **Hara AK**, Leighton JA, Sharma VK, Fleischer DE. Small bowel: preliminary comparison of capsule endoscopy with barium study and CT. *Radiology* 2004; **230**: 260-265
48 **de Mascarenhas-Saraiva MN**, da Silva Araújo Lopes LM. Small-bowel tumors diagnosed by wireless capsule endoscopy: report of five cases. *Endoscopy* 2003; **35**: 865-868
49 **Lewis BS**, Eisen GM, Friedman S. A pooled analysis to evaluate results of capsule endoscopy trials. *Endoscopy* 2005; **37**: 960-965

S- Editor Zhu LH **L- Editors** Zhu LH **E- Editor** Wang HF