Review Article

Capsule Endoscopy in Inflammatory Bowel Disease: Current Applications

Ana-Maria Singeap MD[1,2], Carol Stanciu MD FRCP•[2], Camelia Cojocariu MD[1,2], Catalin Sfarti MD[1,2], Anca Trifan MD[1,2]

Abstract

Since its introduction to clinical practice in 2001, small-bowel capsule endoscopy (SBCE) has become an important investigation procedure in many small bowel pathologies, including both suspected and known Crohn's disease (CD). SBCE has higher diagnostic yield than other radiologic and endoscopic modalities used in evaluation of patients with suspected CD. In addition, SBCE has proved useful, in a non-invasive and safe manner, as a monitoring method for evaluating the severity and extent of lesions, postoperative recurrence, and mucosal healing in patients with known CD. Monitoring of colonic inflammation in patients with ulcerative colitis (UC) using second-generation of colon capsule endoscopy (CCE-2) has also been reported. Besides its advantages, CE also has several limitations such as the inability to obtain biopsies and lack of therapeutic capabilities, hopefully to be overcome in the near future by advances in modern technologies.

Keywords: capsule endoscopy, Crohn's disease, inflammatory bowel disease, ulcerative colitis

Cite this article as: Singeap AM, Stanciu C, Cojocariu C, Sfarti C, Trifan A. Capsule Endoscopy in Inflammatory Bowel Disease: Current Applications. *Arch Iran Med*. 2015; **18(6):** 379 – 383.

Introduction

Since its introduction to clinical practice in 2001, capsule endoscopy (CE) has become the first-line non-invasive diagnostic technique in many small bowel (SB) pathologies. CE allows visualization of the whole SB, considered until then the "black box" of the gastrointestinal (GI) tract and the "final frontier" for endoscopic evaluation. The first capsule endoscope called M2A (i.e., "mouth to anus") was manufactured by Given Diagnostic Imaging, Yoqneam, Israel, and the merits for its design go to, to a similar degree, the Israeli engineer Gavril Iddan and the British gastroenterologist Paul Swain.[1] After the advent of esophageal capsule endoscope (PillCam ESO), M2A was renamed PillCam SB (i.e. "small bowel"). Technical advances have led to the development of second- and third- generation of SBCE which offer improved image quality and tissue coverage, wider view angle, longer battery life, and interpretation efficiency compared to the first-generation. Several other companies have developed SBCE including the Olympus Endocapsule (Olympus Corp., Tokyo, Japan), OMOM pill (Jinshan Science and Technology Company, Chongqing, China), MiroCam (Intromedic Co., Seoul, South Korea), and CapsoCam SV-1 (CapsoVision, Saratoga, CA, USA).[2–5] Comparative studies between PillCam SB and Olympus EndoCapsule or the MiroCam did not show significant differences.[6,7] Specifications of current available capsule endoscopic systems are presented in Table 1. The major clinical indications for CE are evaluation of obscure GI bleeding, iron deficiency anemia, suspected and known Crohn's disease (CD), celiac disease, and suspected small bowel tumor.[8] CE contraindications include patients with dysphagia or swallowing disorder, known or suspected Zenker's diverticulum, gastrointestinal obstruction, strictures, fistulas, pregnancy, and those with cardiac pacemakers although recent evidence suggests that CE can be used safely in such patients.[9] Despite its well-known advantages such as its non-invasive nature, patient comfort, safety, and access to anatomical regions unattainable via conventional endoscopy, CE has also several limitations including the lack of therapeutic capabilities, inability to obtain biopsies and lack of control over its locomotion.

SBCE has become an important tool for the diagnosis and therapeutic decision of a patient with inflammatory bowel disease (IBD). SBCE has a higher diagnostic yield for both suspected and known small bowel CD compared with other diagnostic modalities such as small bowel follow-through, ileocolonoscopy, CT-enterography, and push enteroscopy.[10] The diagnostic advantages of CE include its capacity to directly visualize the mucosa of the entire SB as well as visualization of the incipient lesions. SBCE may alter disease management of patients with known CD by assessing mucosal healing after medical therapy,[11] and it has also been used for reclassification of unclassified IBD[12] or in detecting postoperative CD recurrence.[13]

This review aims to summarize the current applications of CE in IBD patients, particularly in those with small bowel CD.

Role of capsule endoscopy in inflammatory bowel disease

SBCE findings associated with CD

Findings associated with CD on CE examination include aphthae, ulcers, erosions, erythema, loss of villi, mucosal fissures, and strictures, used in different combinations of number and distribution to reach a "diagnosis" of small bowel CD in many heterogeneous studies which have been published since the introduction of SBCE in clinical practice.[14,15] None of these findings is pathognomonic for CD diagnosis, "minor" lesions such as mucosal erosions occurring in two-thirds of patients taking non-steroid anti-inflammatory drugs (NSAIDs) and even in 10% of normal indi-

Authors' affiliations: [1]"Gr. T. Popa" University of Medicine and Pharmacy, Iasi, Romania. [2]"St. Spiridon" Emergency Hospital, Institute of Gastroenterology and Hepatology, 700111 Iasi, Romania.
•Corresponding author and reprints: Carol Stanciu, MD, FRCP, Professor, "St. Spiridon" Emergency Hospital, Independentei 1, 700111, Iasi, Romania. Tel: +40-732-402860, Fax: +40-232-246611, E-mail: stanciucarol@yahoo.com
Accepted for publication: 20 May 2015

Table 1. Specifications of current available capsule endoscopic systems.

Company	Model	Size (LxD) in mm	Weight (g)	Angle of view (degrees) (°)	Frame rate (per second)	Transmission mode	Image sensor	Image resolution (pixels)	Battery life (hours; minutes)
Given Imaging Ltd., Yoqneam, Israel	PillCam SB2	11×26	3.45	156°	2	RF	CMOS	256×256	9 h
	PillCam SB3	11×26	3	156°	6–2	RF	CMOS	256×256	11 h
	PillCam Eso 2	11×26	2.9	169°	9 (18)×2	RF	2×CMOS	256×256	20 min
	PillCam Colon 2	11×31	2.9	172°	35–4	RF	2×CMOS	256×256	10 h
Olympus Medical System Co., Tokyo, Japan	EndoCapsule 10	11×26	3.3	160°	2	RF	CCD	1080×1920	12 h–8
Chongding Jinshan Science and Technology Co., Beijing, China	OMOM	13×27.9	6	140°	2	RF	CCD	480×640	9 h–7
Intromedic, Seoul, South Korea	MiroCam	11×24	3.3	150°	3	EFP	CMOS	320×320	12 h–10

L = length; D = diameter; RF = radio frequency; CMOS = complementary metal-oxide-semiconductor; CCD = charge-coupled device; EFP = electric field propagation.

Table 2. Lewis capsule endoscopy scoring index.[18]

	Parameters	Number	Longitudinal extent	Descriptors
First tertile	Villous appearance	Normal = 0 Edematous = 1	Short segment = 8 Long segment = 12 Whole segment = 20	Single = 1 Patchy = 14 Diffuse = 17
	Ulcer	None = 0 Single = 3 Few = 5 Multiple = 10	Short segment = 8 Long segment = 12 Whole segment = 20	<1/4 = 9 ¼ to ½ = 12 >1/2 = 18
Second tertile	Villous appearance	Normal = 0 Edematous = 1	Short segment = 8 Long segment = 12 Whole segment = 20	Single = 1 Patchy = 14 Diffuse = 17
	Ulcer	None = 0 Single = 3 Few = 5 Multiple = 10	Short segment = 8 Long segment = 12 Whole segment = 20	<1/4 = 9 ¼ to ½ = 12 >1/2 = 18
Third tertile	Villous appearance	Normal = 0 Edematous = 1	Short segment = 8 Long segment = 12 Whole segment = 20	Single = 1 Patchy = 14 Diffuse = 17
	Ulcer	None = 0 Single = 3 Few = 5 Multiple = 10	Short segment = 8 Long segment = 12 Whole segment = 20	<1/4 = 9 ¼ to ½ = 12 >1/2 = 18
Stenosis-rated for whole study	Stenosis	None = 0 Single = 14 Multiple = 12	Ulcerated = 24 Non-ulcerated = 2	Traversed = 7 Not traversed = 10

viduals.[16] As the lesions seen at CE in patients suspected with CD were heterogeneously described in published studies, a capsule endoscopy structured terminology (CEST) has been proposed to be used for lesion description detected by CE.[17] In order to objectively evaluate the various findings on CE, several diagnostic scores have been proposed.[18,19] The Lewis score[18] divides the SB into three tertiles (proximal, middle, and distal), and disease severity is based on three endoscopic criteria: villous edema, ulceration, and stenosis (Table 2). The worst affected tertile is taken as the overall score. A Lewis score <135 is considered normal, one between 135 and 790 is considered mild, while one higher than 790 indicates moderate-to-severe disease activity. This score is incorporated into the RAPID® software from the PillCam (Given® Imaging Ltd., Yoqneam, Israel). A similar scoring system called CECDAI (Capsule Endoscopy Crohn's Disease Activity Index) divides the SB into two halves (proximal and distal) and again uses three endoscopic criteria to grade disease severity: inflammation, extent of disease, and presence of strictures[19] (Table 3). Unfortunately, none of the scoring systems correlates with clinical indices of disease activity such as CDAI (Crohn's Disease Activity Index). Nevertheless, scoring systems may be useful tools to evaluate SB mucosal healing in response to medical therapy.[20]

SBCE versus other techniques for the diagnosis of CD

The diagnosis of CD is based on a combination of clinical, radiologic, endoscopic, and histologic findings. In the past, small bowel follow-through (SBFT) was the main contrast imaging diagnostic technique; more recently, computed tomography (CT)-

Table 3. Capsule endoscopy Crohn's disease activity index scoring system.[19]

Proximal	Distal	
Inflammation score	A.	0 = None 1 = Mild to moderate edema/hyperemia/denudation 2 = Severe edema/hyperemia/denudation 3 = Bleeding, exudates, aphthae, erosion small ulcer (<0.5 cm) 4 = Moderate ulcer (0.5–2 cm), pseudopolyp 5 = Large ulcer (>2 cm)
Extent of disease score	B.	0 = None 1 = Focal disease (single segment) 2 = Patchy disease (multiple segments) 3 = Diffuse disease
Narrowing (stricture)	C.	0 = None 1 = Single-passed 2 = Multiple-passed 3 = Obstruction
Segmental score = A x B + C; total score = (A1 × B1 + C1) + (A2 × B2 + C2)		

Table 4. Diagnostic yield of capsule endoscopy for Crohn's disease.

Diagnostic modalities	Study	Yield of CE	Yield of compared modality	Comments (Number of patients)
SBFT	Eliakim, *et al.*[40]	77%	23%	35 patients with suspected CD
	Buchman, *et al.*[41]	70%	67%	30 patients (S = 0, K = 30)
	Dubcenco, *et al.*[42]	67%	21%	11 patients with suspected CD
	Hara, *et al.*[43]	71%	24%	17 patients (S = 8, K = 9)
Enteroclysis	Efthymiou, *et al.*[44]	67%	36%	47 patients (S = 6, K = 29)
	Marmo, *et al.*[45]	71%	26%	31 patients (S = 0, K = 31)
	Chong, *et al.*[46]	49%	12%	43 patients (S = 21, K = 22)
	Albert, *et al.*[47]	93% (K diagnosis)	67% (K diagnosis)	52 patients (S = 25, K = 27)
CT enteroclysis	Voderholzer, *et al.*[48]	61%	29%	41 patients (S = 0, K = 41)
CT-enterography	Eliakim, *et al.*[40]	77%	50%	35 patients (S = 35, K = 0)
	Hara, *et al.*[43]	71%	53%	17 patients (S = 8, K = 9)
	Jensen, *et al.*[23]	30%	33%	80 patients
MR-enterography	Golder, *et al.*[49]	76%	41%	18 patients (S = 2, K = 16)
	Tillack, *et al.*[50]	95%	95%	19 (S = 0, K = 19)
	Albert, *et al.*[47]	93%	88%	
SBFT = small-bowel follow-through; S = suspected; K = known; CE = capsule endoscopy; CD = Crohn's disease.				

and magnetic resonance (MR)-enterography have improved the accuracy of SB imaging examination. However**,** ileocolonoscopy with biopsy remains the gold standard for diagnosis of CD (21). Table 4 summarizes the diagnostic yield of CE for both suspected and known CD compared with other diagnostic modalities.

Suspected CD. A large meta-analysis including 11 trials showed CE to have higher diagnostic yields than SBFT (63% vs. 23%), ileocolonoscopy (61% vs. 46%), or CT-enterography in patients with suspected or established SBCD.[22] In a more recent meta-analysis including patients with both suspected and known CD, CE showed higher diagnostic yields compared with SBFT (52% vs. 16%), CT-enterography (68% vs. 21%) and ileocolonoscopy (47% vs. 25%) in those with suspected CD, and to SBFT (71% vs. 36%), CT-enterography (71% vs. 39%) and push enteroscopy (66% vs. 9%) in those with known CD.[10] A recent prospective study comparing diagnostic accuracy of CE with CT-enterography and MR-enterography for SBCD using ileoscopy or surgery as the gold standard found sensitivity values of 100% for CE, 81% for MR-enterography and 76% for CT-enterography.[23]

As mentioned above, according to current guidelines and consensus of experts.[21,24] ileocolonoscopy remains the first diagnostic modality for patients with suspected CD. If ileocolonoscopy is normal, and in the absence of symptoms of obstruction, the next step should be a patency capsule or CT-enterography or MR-enterography.[25]

Known CD. SBCE has also been shown to have a high diagnostic yield in patients with known small bowel CD. The main concern in using CE in such patients is the high risk of capsule retention due to the bowel strictures. Retention rates vary from 1%–2% in patients with suspected CD to 5%–13% in those with known disease.[26] Consequently, before performing a SBCE examination in patients with known CD, bowel strictures should be ruled out by using patency capsule or a SB imaging technique (SBFT, CT- or MR-enterography). However, it should be underlined that even in the presence of a normal SB radiologic examination, undetected bowel strictures and thus the risk of capsule retention still remain.[27] Persistent capsule retention requires endoscopic retrieval[28] or surgical intervention.

In patients with known CD, SBCE may be better used as a method for monitoring the extent and activity of the disease, postoperative recurrence, and mucosal healing rather than establishing the

initial diagnosis.[13] In addition, CE may also be helpful in providing a more definitive diagnosis for reclassification of unclassified IBD.[12]

Monitoring of mucosal healing. Healing of the bowel mucosa, defined as the absence of inflammation at endoscopy, has recently emerged as the primary objective of medical therapy in IBD. Mucosal healing is considered a strong marker of favorable long-term outcome, associated with fewer complications and surgical interventions.[29] Only a handful of studies have used SBCE to assess mucosal healing in response to medical therapy.[11,20,30] One study using SBCE found no correlation between clinical response and mucosal healing in CD patients,[9] while another study, using the Lewis score, found that SBCE was an effective method to monitor the mucosal response.[20]

CE findings can change medical therapy in patients with IBD. Thus, in one study, therapy was changed in over half of patients with CD after CE examination.[31] However, it remains to be established if mucosal findings as assessed by CE in patients with CD should be followed by change in therapy similar to that of ileocolonoscopy.

Assessing postoperative CD recurrence. Endoscopic recurrence of CD occurs in up to 90% of patients after one year from surgical intervention.[32] CE seems to be a good option for identification of CD recurrences proximal to the surgical anastomosis which are not always accessible via colonoscopy, and also in patients who do not wish to undergo colonoscopy or when colonoscopy is contraindicated. There are studies reporting higher yield of CE for identification of lesions proximal to the surgical anastomosis (usually not accessible to colonoscopy),[33] while others found that CE had lower sensitivity for detecting preanastomotic lesions in the neo-terminal ileum.[34] Although CE is an attractive non-invasive method for the diagnosis of postoperative CD recurrence, ileocolonoscopy still remain the gold-standard for defining the presence of recurrence.

SBCE for classification of IBD unclassified. At least 10% of colonic IBD patients cannot be classified as CD or UC only by colonoscopic and biopsy findings. During the course of their illness, some of these patients with "undetermined colitis" will be reclassified as CD after identification of SB involvement. SBCE is a useful method in providing the presence of small-bowel lesions suggestive for CD, and thus, to allow some of IBD unclassified patients to be reclassified as CD.[12]

Ulcerative colitis

Colon capsule endoscopy (CCE) has been developed mainly for colorectal cancer screening, but the results with first generation CCE (CCE-1) have been disappointing as compared with standard colonoscopy.[35] The second-generation CCE (CCE-2) has improved image quality and provided wider view angle compared with CCE-1. Obviously, the diagnosis of UC does not require CE. However, CCE-2 may be useful in assessing mucosal inflammation in UC patients. Recently, Hosoe, *et al.*[36] have evaluated the severity of mucosal inflammation in patients with UC using CCE-2 with a low-volume (2 L) polyethylene glycol with prokinetics preparation regimen. The authors found that CCE-2 might be feasible for assessing the severity of mucosal inflammation in patients with UC. Another single-center study evaluating CCE in detecting the severity and extent of active UC in comparison with standard endoscopy, found a significant correlation in severity ($P < 0.001$) and extent ($P < 0.001$) of UC between these two methods.[37] A multicenter study assessing colonic inflammation (defined as the presence of ulcers, erythema, erosions, edema in mucosa) using CCE-1 and colonoscopy as the gold standard, reported that the sensitivity and specificity of CCE in detecting active colonic inflammation were 89% and 75%, respectively, and suggested that although CCE is a safe procedure to monitor mucosal healing in UC, it cannot replace conventional colonoscopy in the management of patients with UC.[38] Finally, some studies have evaluated SB inflammation in patients with UC and found that more than half of them had SB lesions[39]; however, the clinical significance of these lesions remains unclear.[15] Besides its advantages (non-invasive nature, safety, high level of patient acceptance), CCE has also several limitations including the inability to take biopsy; therefore, it is not appropriate for surveillance for colorectal cancer in UC patients.

Conclusion

Since its introduction to clinical practice more than a decade ago, SBCE has become an established investigation procedure in the diagnosis and management of both suspected and known CD. Offering a non-invasive and enhanced direct visualization of the entire small-bowel mucosa, SBCE has been demonstrated to be superior to other diagnostic modalities such as small bowel radiology (SBFT, CT-enterography and MR-enterography) and endoscopy (push enteroscopy, ileocolonoscopy). Besides its high diagnostic yield, SBCE is also useful as a method to evaluate the severity and extent of lesions, mucosal healing after medical therapies, and postoperative recurrence in patients with known CD.

CCE has been developed for colorectal screening, as the diagnosis of UC does not require CE. Because CCE is a purely visual technique with no ability to take biopsy, it cannot be used for surveillance for colorectal cancer in patients with UC.

References

1. Iddan G, Meron G, Glukhovsky A, Swain P. Wireless capsule endoscopy. *Nature.* 2000; **405:** 417.
2. Rey JF, Kuznetsov K, Vazquez-Ballesteros E. Olympus capsule endoscope for small and large bowel exploration. *Gastrointest Endosc.* 2006; **63:** AB176.
3. Liao Z, Gao R, Li F, Xu C, Zhou Y, Wang JS, et al. Fields of applications, diagnostic yields and findings of OMOM capsule endoscopy in 2400 Chinese patients. *World J Gastroenterol.* 2010; **16:** 2669 – 2676.
4. Bang S, Park JY, Jeong S, Kim YH, Shim HB, Kim TS, et al. First clinical trial of the "MiRo" capsule endoscope by using a novel transmission technology: electric field propagation. *Gastrointest Endosc.* 2009; **69:** 253 – 259.
5. Friedrich K, Gehrke S, Stremmel W, Sieg A. First clinical trial of a newly developed capsule endoscope with panoramic side view for small bowel: a pilot study. *J. Gastroenterol Hepatol.* 2013; **28:** 1496 – 1501.
6. Cave DR, Fleischer DE, Leighton JA, Faigel DO, Heigh RI, Sharma VK, et al. A multicenter randomized comparison of the Endocapsule and the Pillcam SB. *Gastrointest Endosc.* 2008; **68:** 487 – 494.
7. Pioche M, Gaudin JL, Filoche B, Jacob P, Lamouliatte H, Lapalus MG, et al. French Society of Digestive Endoscopy. Prospective, randomized comparison of two small-bowel capsule endoscopy systems in patients with obscure GI bleeding. *Gastrointest Endosc.* 2011; **73:** 1181 – 1188.
8. Bouchard S, Ibrahim M, Van Gossum A. Video capsule endoscopy: perspectives of a revolutionary technique. *World J Gastroenterol.* 2014; **20:** 17330 – 17344.
9. Harris LA, Hansel SL, Rajan E, Srivathsan K, Rea R, Crowell MD, et al. Capsule Endoscopy in Patients with Implantable Electromedical Devices is Safe. *Gastroenterol Res Pract.* 2013; **2013:** 959234.
10. Dionisio PM, Gurudu SR, Leighton JA, Leontiadis GI, Fleischer DE, Hara AK, et al. Capsule endoscopy has a significantly higher diagnostic yield in patients with suspected and established small-bowel

Crohn's disease: a meta-analysis. *Am J Gastroenterol*. 2010; **105:** 1240 – 1248.
11. Efthymiou A, Viazis N, Mantzaris G, Papadimitriou N, Tzourmakliotis D, Raptis S, et al. Does clinical response correlate with mucosal healing in patients with Crohn's disease of the small bowel? A prospective, case-series study using wireless capsule endoscopy. *Inflamm Bowel Dis.* 2008; **14:** 1542 – 1547.
12. Lopes S, Figueiredo P, Portela F, Freire P, Almeida N, Lérias C, et al. Capsule endoscopy in inflammatory bowel disease type unclassified and indeterminate colitis serologically negative. *Inflamm Bowel Dis*. 2010; **16:** 1663 – 1668.
13. Doherty GA, Moss AC, Cheifetz AS. Capsule endoscopy for small-bowel evaluation in Crohn's disease. *Gastrointest Endosc*. 2011; **74:** 167 – 175.
14. Swaminath A, Legnani P, Kornbluth A. Video Capsule Endoscopy in Inflammatory Bowel Disease: Past, Present, and Future Redux. *Inflamm Bowel Dis*. 2010; **16:** 1254 – 1262.
15. Kopylov U, Seidman EG. Role of capsule endoscopy in inflammatory bowel disease. *World J Gastroenterol*. 2014; **20:** 1155 – 1164.
16. Sidhu R, Brunt LK, Morley SR, Sanders DS, McAlindon ME. Undisclosed use of nonsteroidal anti-inflammatory drugs may underlie small-bowel injury observed by capsule endoscopy. *Clin Gastroenterol Hepatol*. 2010; **8:** 992 – 995.
17. Korman LY, Delvaux M, Gay G, Hagenmuller F, Keuchel M, Friedman S, et al. Capsule endoscopy structured terminology (CEST): proposal of a standardized and structured terminology for reporting capsule endoscopy procedures. *Endoscopy*. 2005; **37:** 951 – 959.
18. Gralnek IM, Defranchis R, Seidman E, Leighton JA, Legnani P, Lewis BS. Development of a capsule endoscopy scoring index for small bowel mucosal inflammatory change. *Aliment Pharmacol Ther*. 2008; **27:** 146 – 154.
19. Niv Y, Ilani S, Levi Z, Hershkowitz M, Niv E, Fireman Z, et al. Validation of the Capsule Endoscopy Crohn's Disease Activity Index (CECDAI or Niv score): a multicenter prospective study. *Endoscopy.* 2012; **44:** 21 – 26.
20. Niv E, Fishman S, Kachman H, Arnon R, Dotan I. Sequential capsule endoscopy of the small bowel for follow-up of patients with known Crohn's disease. *J Crohns Colitis.* 2014; **8:** 1616 – 1623.
21. Annese V, Daperno M, Rutter MD, Amiot A, Bossuyt P, East J, et al. European Crohn's and Colitis Organisation, European evidence based consensus for endoscopy in inflammatory bowel disease. *J Crohns Colitis.* 2013; **7:** 982 – 1018.
22. Triester SL, Leighton JA, Leontiadis GI, Gurudu SR, Fleischer DE, Hara AK, et al. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with non-stricturing small bowel Crohn's disease. *Am J Gastroenterol.* 2006; **101:** 954 – 964.
23. Jensen MD, Nathan T, Rafaelsen SR, Kjeldsen J. Diagnostic accuracy of capsule endoscopy for small bowel Crohn's disease is superior to that of MR enterography or CT enterography. *Clin Gastroenterol Hepatol.* 2011; **9:** 124 – 129.
24. Mergener K, Ponchon T, Gralnek I, Pennazio M, Gay G, Selby W, et al. Literature review and recommendations for clinical application of small-bowel capsule endoscopy, based on a panel discussion by international experts: consensus statements for small-bowel capsule endoscopy, 2006/2007. *Endoscopy*. 2007; **39:** 895 – 909.
25. Gerson LB. Use and misuse of small bowel video capsule endoscopy in clinical practice. *Clin Gastroenterol Hepatol*. 2013; **11:** 1224 – 1231.
26. Cheifetz AS, Kornbluth AA, Legnani P, Schmelkin I, Brown A, Lichtiger S, et al. The risk of retention of the capsule endoscope in patients with known or suspected Crohn's disease. *Am J Gastroenterol*. 2006; **101:** 2218 – 2222.
27. Figueiredo P, Almeida N, Lopes S, Duque G, Freire P, Lérias C, et al. Small-bowel capsule endoscopy in patients with suspected Crohn's disease-diagnostic value and complications. *Diagn Ther Endosc*. 2010; DOI: 10.1155/2010/101284.
28. Van Weyenberg SJ, Van Turenhout ST, Bouma G, Van Waesberghe JH, Van der Peet DL, Mulder CJ, et al. Double-balloon endoscopy as the primary method for small-bowel video capsule endoscope retrieval. *Gastrointest Endosc*. 2010; **71:** 535 – 541.
29. Pineton de Chambrun G, Peyrin-Biroulet L, Lémann M, Colombel JF. Clinical implications of mucosal healing for the management of IBD. *Nat Rev Gastroenterol Hepatol.* 2010; **7:** 15 – 29.
30. Hall B, Holleran G, Chin JL, Smith S, Ryan B, Mahmud N, et al. A prospective 52 week mucosal healing assessment of small bowel Crohn's disease as detected by capsule endoscopy. *J Crohns Colitis.* 2014; **8:** 1601 – 1609.
31. Lorenzo-Zúñiga V, de Vega VM, Domènech E, Cabré E, Mañosa M, Boix J. Impact of capsule endoscopy findings in the management of Crohn's Disease. *Dig Dis Sci.* 2010; **55:** 411 – 414.
32. Rutgeerts P, Geboes K, Vantrappen G, Beyls J, Kerremans R, Hiele M. Predictability of the postoperative course of Crohn's disease. *Gastroenterology.* 1990; **99:** 956 – 963.
33. Pons Beltran V, Nos P, Bastida G, Beltran B, Arguello L, Aguas M, et al. Evaluation of postsurgical recurrence in Crohn's disease: a new indication for capsule endoscopy? *Gastrointest Endosc*. 2007; **66:** 533 – 540.
34. Bourreille A, Jarry M, D'Halluin PN, Ben-Soussan E, Maunoury V, Bulois P, et al. Wireless capsule endoscopy versus ileocolonoscopy for the diagnosis of postoperative recurrence of Crohn's disease: a prospective study. *Gut*. 2006; **55:** 978 – 983.
35. Van Gossum A, Munoz-Navas M, Fernandez-Urien I, Carretero C, Gay G, Delvaux M, et al. Capsule endoscopy versus colonoscopy for the detection of polyps and cancer. *N Engl J Med*. 2009; **361:** 264 – 270.
36. Hosoe N, Matsuoka K, Naganuma M, Ida Y, Ishibashi Y, Kimura K, et al. Applicability of second-generation colon capsule endoscope to ulcerative colitis: a clinical feasibility study. *J Gastroenterol Hepatol*. 2013; **28:** 1174 – 1179.
37. Ye CA, Gao YJ, Ge ZZ, Dai J, Li XB, Xue HB, et al. PillCam colon capsule endoscopy versus conventional colonoscopy for the detection of severity and extent of ulcerative colitis. *J Dig Dis*. 2013; **14:** 117 – 124.
38. Sung J, Ho KY, Chiu HM, Ching J, Travis S, Peled R. The use of Pillcam Colon in assessing mucosal inflammation in ulcerative colitis: a multicenter study. *Endoscopy.* 2012; **44:** 754 – 758.
39. Higurashi T, Endo H, Yoneda M, Hosono K, Sakai E, Takahashi H, et al. Capsule-endoscopic findings of ulcerative colitis patients. *Digestion.* 2011; **84:** 306 – 314.
40. Eliakim R, Suissa A, Yassin K, Katz D, Fischer D. Wireless capsule video endoscopy compared to barium follow-through and computerised tomography in patients with suspected Crohn's disease--final report. *Dig Liver Dis.* 2004; **36:** 519 – 522.
41. Buchman AL, Miller FH, Wallin A, Chowdhry AA, Ahn C. Video-capsule endoscopy versus barium contrast studies for the diagnosis of Crohn's disease recurrence involving the small intestine. *Am J Gastroenterol*. 2004; **99:** 2171 – 2177.
42. Dubcenco E, Jeejeebhoy KN, Petroniene R, Tang SJ, Zalev AH, Gardiner GW, et al. Capsule endoscopy findings in patients with established and suspected small-bowel Crohn's disease: correlation with radiologic, endoscopic, and histologic findings. *Gastrointest Endosc*. 2005; **62:** 538 – 544.
43. Hara AK, Leighton JA, Heigh RI, Sharma VK, Silva AC, De Petris G, et al. Crohn disease of the small bowel: preliminary comparison among CT enterography, capsule endoscopy, small-bowel follow-through, and ileoscopy. *Radiology*. 2006; **238:** 128 – 134.
44. Efthymiou A, Viazis N, Vlachogiannakos J, Georgiadis D, Kalogeropoulos I, Mantzaris G, et al. Wireless capsule endoscopy versus enteroclysis in the diagnosis of small-bowel Crohn's disease. *Eur J Gastroenterol Hepatol*. 2009; **21:** 866 – 871.
45. Marmo R, Rotondano G, Piscopo R, Bianco MA, Siani A, Catalano O, et al. Capsule endoscopy versus enteroclysis in the detection of small-bowel involvement in Crohn's disease: a prospective trial. *Clin Gastroenterol Hepatol*. 2005; **3:** 772 – 776.
46. Chong AK, Taylor A, Miller A, Hennessy O, Connell W, Desmond P. Capsule endoscopy vs. push enteroscopy and enteroclysis in suspected small-bowel Crohn's disease. *Gastrointest Endosc*. 2005; **61:** 255 – 261.
47. Albert JG, Martiny F, Krummenerl A, Stock K, Lesske J, Göbel CM, et al. Diagnosis of small bowel Crohn's disease: a prospective comparison of capsule endoscopy with magnetic resonance imaging and fluoroscopic enteroclysis. *Gut*. 2005; **54:** 1721 – 1727.
48. Voderholzer WA, Beinhoelzl J, Rogalla P, Murrer S, Schachschal G, Lochs H, et al. Small bowel involvement in Crohn's disease: a prospective comparison of wireless capsule endoscopy and computed tomography enteroclysis. *Gut.* 2005; **54:** 369 – 373.
49. Gölder SK, Schreyer AG, Endlicher E, Feuerbach S, Schölmerich J, Kullmann F, et al. Comparison of capsule endoscopy and magnetic resonance (MR) enteroclysis in suspected small bowel disease. *Int J Colorectal Dis.* 2006; **21:** 97 – 104.
50. Tillack C, Seiderer J, Brand S, Göke B, Reiser MF, Schaefer C, et al. Correlation of magnetic resonance enteroclysis (MRE) and wireless capsule endoscopy (CE) in the diagnosis of small bowel lesions in Crohn's disease. *Inflamm Bowel Dis*. 2008; **14:** 1219 – 1228.