European Society of Gastrointestinal Endoscopy (ESGE): Recommendations (2009) on clinical use of video capsule endoscopy to investigate small-bowel, esophageal and colonic diseases

Authors   S. D. Ladas[1], K. Triantafyllou[1], C. Spada[2], M. E. Riccioni[2], J.-F. Rey[3], Y. Niv[4], M. Delvaux[5], R. de Franchis[6], G. Costamagna[2] and the ESGE Clinical Guidelines Committee

Institutions   Institutions are listed at the end of article.

Corresponding author
S. D. Ladas, MD
First Department of Internal
Medicine-Propaedeutic
Laiko General Hospital
of Athens
Medical School,
Athens University
Athens, Greece
Fax: +30-210-7225882
sdladas@otenet.gr

These recommendations on video capsule endoscopy, an emerging technology with an impact on the practice of endoscopy, were developed by the European Society of Gastrointestinal Endoscopy (ESGE) Guidelines Committee. The first draft of each section was prepared by one or two members of the writing team, who were selected as experts on the content of that section on the basis of their published work. They used evidence-based methodology, performing MEDLINE and PubMed literature searches to identify relevant clinical studies. Abstracts from scientific meetings were included only if there was no published full paper on a particular topic. If there was disagreement, the first author of the Guideline made the final decision. Recommendations were graded according to the strength of the supporting evidence (O **Table 1**) [1]. The draft guideline was critically reviewed by all authors and submitted to the ESGE councillors for their critical review before approval of the final document. The ESGE Guidelines Committee acknowledges that this document is based on a critical review of the data available at the time of preparation and that further studies may be needed to clarify some aspects. Moreover, this Guideline may be revised as necessary to account for changes in technology, new data, or other aspects of clinical practice. This document should be regarded as supplying recommendations only to gastroenterologists in providing care to their patients. It is not a set of rules and should not be construed as establishing a legal standard of care, or as encouraging, advocating, requiring, or discouraging any particular treatment. These recommendations must be interpreted according to the clinician's knowledge, expertise, and clinical judgment in the management of individual patients and, if necessary, a course of action that varies from recommendations must be undertaken.

Introduction
▼

Video capsule endoscopy (VCE) for diseases of the small intestine was introduced into clinical practice in 2001. Over the past 8 years, an annually increasing number of publications have shown that VCE is a reliable, noninvasive method for endoscopic examination of the entire small-bowel mucosa. An esophageal [2] and a colon capsule [3] have also been launched on the market and are under intensive clinical investigation.

The aim is to update the previous document published over 3 years ago, in 2006 [4]. The updated recommendations are presented in O **Table 2**.

Video capsule system
▼

The VCE system consists of: (i) a capsule containing the video camera; (ii) a sensing system comprising an array of sensor pads, a data recorder, and a battery pack; and (iii) a workstation, based on a commercially available personal computer. There is also a portable external viewer for directly monitoring the images received during the examination.

In the last 3 years there have been several technological advances, both in the capsule itself and the associated hardware and software, that have greatly improved image quality and battery lifespan. Currently, capsule endoscopy systems are manufactured by four companies.

Given Imaging Ltd (Israel) first delivered wireless capsule endoscopy in 2001. Today, capsule endoscopy devices from Given Imaging include the PillCam SB for the small intestine, the PillCam ESO for

Grade of recommendation	Categories of evidence		Types of study
A	1	1a	Systematic review of randomized controlled trials of good methodological quality and with homogeneity
		1b	At least one randomized controlled trial with narrow confidence interval
B	2	2a	At least one well designed controlled study without randomization
		2b	Noncontrolled cohort studies
	3	3a	Systematic review of case–control studies (with homogeneity)
		3b	Individual case–control study
C	4	4	Case series/poor quality cohort or case controlled studies
D	5	5	Expert committee reports or opinions, or clinical experiences of respected authorities

Table 1 Categories of evidence and grades of recommendation (adapted from reference [1]).

Table 2 The 2009 European Society of Gastrointestinal Endoscopy (ESGE) updated information for video capsule endoscopy (VCE).

Statements	Category of evidence	Grade of recommendation
Small-bowel preparation		
Purgative bowel preparation enhances the diagnostic yield of small-bowel VCE [5], but does not affect VCE completion rate [6 – 8]	2a	B
Obscure gastrointestinal bleeding		
VCE is the first-line examination in obscure gastrointestinal bleeding (OGIB) after a negative upper and lower gastrointestinal endoscopy [9 – 21]	2b	B
Patients with unexplained iron-deficiency anemia should undergo small-bowel VCE examination [22]	2b	B
Crohn's disease		
VCE is the best procedure to evaluate small-bowel mucosal lesions in Crohn's disease [23]	3a	B
The risk for capsule retention in suspected or established Crohn's disease is high. Small-bowel imaging or patency capsule should precede VCE [24, 25]	2b	B
Nonsteroidal anti-inflammatory drugs (NSAIDs) should be stopped 2 months prior to VCE [26]	2a	B
Celiac disease		
VCE has a high diagnostic yield in patients with suspected celiac disease [27 – 29]	2b	B
Patients with refractory or complicated (jejunoileitis, intestinal lymphoma) celiac disease should have a VCE examination [30, 31]	2b	B
Polyposis syndromes and small-bowel tumors		
VCE should be considered to be a first-line screening modality for surveillance in patients with Peutz–Jeghers syndrome [32 – 35]	2b	B
VCE examination of the small bowel is indicated in familial adenomatous polyps (FAP) patients with duodenal polyps [36 – 38]	2b	B
VCE examination influences the therapeutic work-up of small-bowel tumors [39, 40]	3b	B
Esophageal VCE		
VCE has good agreement with conventional esophagogastroduodenoscopy (EGD) in diagnosing Barrett's esophagus and esophageal varices [41 – 43]	2a	B

esophageal imaging and Pillcam Colon for the large bowel. More recently, Olympus (Japan) have produced the EndoCapsule for the small bowel; IntroMedic (Korea) have developed the MiRo-Cam for small-bowel evaluation using electric-field propagation for data transmission [44], and, finally, the Chongqing Jinshan Science and Technology Group (China) have launched the OMOM small-bowel capsule.

Whilst the PillCam captures images using a complementary metal oxide silicon (CMOS) sensor, the EndoCapsule, MiroCam, and OMOM capsule use a charge-coupled device (CCD). The four capsules also differ with regard to dimensions, image acquisition frame rate, field of view, and recording duration (○ **Table 3**).

Almost all of the information provided in this document is based on published data regarding the Given Imaging PillCams. Data concerning the EndoCapsule are scarce in the literature [45 – 47], and there is even less concerning the other two systems [5, 44, 48].

	Pillcam SB2	EndoCapsule	MiroCam	OMOM capsule	Table 3 Technical specifications of small-bowel capsules.
Length, mm	26	26	24	27.9	
Diameter, mm	11	11	11	13	
Weight, g	3.4	3.8	3.4	6	
Frame rate, frames/second	2	2	3	0.5–2	
Image sensor	CMOS	CCD	CCD	CCD	
Field of view	156°	145°	150°	140°	
Illumination	6 white LEDs	6 white LEDs	6 white LEDs	NA	
Antennas (body leads), n	8	8	9	14	
Real-time (RT) view	RT viewer	VE-1 viewer	Miro-Viewer	RT monitoring	
Recording time, hours	8	9	11	7 – 9	

CMOS, complementary metal oxide semiconductor; CCD, charge-coupled device; LED, light-emitting diode; NA, not applicable

Patency capsule
▼

The patency system of Given Imaging (Yoqneam, Israel) consists of: (i) a self-disintegrating capsule (the AGILE capsule), without a camera but containing a radiofrequency identification (RFID) tag; and (ii) a RFID scanner. The AGILE capsule, which replaced the M2A patency capsule, is identical in size to the small-bowel PillCam (26 mm long, 11 mm wide). This solid, biodegradable capsule contains the small RFID tag (2 × 12 mm) within a radio-opaque lactose and barium body. This body is coated with an impermeable membrane of parylene except for two small windows; these allow luminal fluid access to paraffin timer plugs to bring about disintegration of the capsule within 30 hours [49, 50]. The capsule remnants can pass through even small orifices. The RFID tag within the capsule transmits signals that are detected by the RFID scanner. Detection of a radiofrequency signal by the scanner indicates that the capsule is still in the gastrointestinal tract. The radio-opaque capsule can be detected by plain abdominal X-ray.

The AGILE capsule has been shown to provide evidence of the functional patency of the gastrointestinal tract in patients with known or suspected intestinal stricture [49]. Functional patency is verified by this test if the AGILE capsule is egested intact without any change in its original dimensions, irrespective of the time of expulsion, or, if the RFID tag is not detected when the patient is scanned at 32 – 38 hours. Patients at high risk who develop pain during the AGILE capsule test are not eligible for VCE examination [49].

Small-bowel video capsule endoscopy (VCE)
▼
Small-bowel preparation

The preparation for VCE suggested by manufacturers of capsule endoscopy systems consists only of a clear liquids diet and an 8-hour fast. However, two factors that impair the diagnostic yield of VCE are first, the presence of food residue, air bubbles and turbid or green viscous intraluminal fluid, and secondly failure of the capsule to visualize all of the small-bowel due to delayed gastric or small-bowel transit times. In some studies therefore purgatives have been used, to clean the small-bowel mucosa, but results have been inconclusive. A recent meta-analysis has shown that small-bowel purgative preparation (polyethylene glycol solution or sodium phosphate) improves the diagnostic yield of the examination [6]. It also showed better quality of visualization of the mucosa in patients receiving purgatives, but there was sig-

nificant heterogeneity between the nine sets of data. The meta-analysis did not detect any difference between purgative preparation and clear liquids diet regarding VCE completion rate, VCE gastric transit time (GTT), and VCE small-bowel transit time (SBTT) [6].

Another meta-analysis and a systematic review that examined the effectiveness of bowel preparation for VCE also included studies using prokinetics and simethicone (in contrast to the previous study). The first one (on seven studies) did not address the important issue of VCE diagnostic yield [7]. The second (on 14 studies), published in abstract form, showed that bowel preparation had no effect on VCE diagnostic yield [8]. However, both studies [7, 8] are in agreement with Rokkas et al. [6], regarding the effects of bowel preparation on the quality of mucosal visualization, on VCE transit times, and on the completion rate of the examination.

While there is evidence for a benefit from bowel preparation for VCE, there is so far no consensus on the preparation regimen. Several investigators favor half-doses of purgatives in the evening before the examination, others prefer a colonoscopy-like preparation while some advocate administration of the preparation even during the examination [51, 52]. In a well-designed randomized controlled trial, the administration of simethicone in order to reduce air bubbles has been shown to improve visibility of the mucosa of at least the proximal part of the small bowel during VCE recording [53]. Nevertheless, the 2006/2007 consensus statements for small-bowel capsule endoscopy [54] did not report consistent clinical benefit for these agents.

Although adverse events and patient intolerance might be associated with the use of bowel purge for VCE, as inferred from colonoscopy studies, these have not yet been reported [54]. Moreover, the largest published meta-analysis on bowel preparation for VCE [6] has not detected clinically significant adverse events related to bowel preparation. In conclusion, small-bowel preparation before VCE seems to improve the visibility of the small-bowel mucosa, without any difference in terms of VCE completion rate or capsule GTT and SBTT. The data from the meta-analysis also show that small-bowel preparation improves the diagnostic yield of VCE [6].

VCE completion rate

Small-bowel VCE completion rate is about 80 % [6]. Retrospective studies have identified factors such as inpatient status [55, 56], previous abdominal surgery [56], poor bowel cleansing [56] and prolonged GTT [56] that may predict incomplete small-bowel VCE examination, while the effects of diabetes mellitus [55, 57]

and of greater age are controversial [55, 58]. Patients at increased risk for incomplete examination might benefit from the use of the real-time viewer periprocedurally and then intervention with endoscopic placement of the capsule in the duodenum [56, 59]. There has been promising use of the real-time viewer to optimize the timing of bowel preparation, thus improving its quality [52], but this has not been studied extensively yet.

Indications
▼
Obscure gastrointestinal bleeding

Obscure gastrointestinal bleeding (OGIB) is the most frequent indication for small-bowel VCE examination. The yield of VCE in patients with OGIB is significantly higher for patients with ongoing overt bleeding compared with patients with obscure occult bleeding. The diagnostic yield is also higher when the examination is performed within 48 hours of patient hospitalization for the bleeding episode [9].

The rate of rebleeding in patients with OGIB and negative VCE is significantly lower (4.6%) compared with those with a positive VCE (48%) [10].

A large retrospective survey from the Mayo Clinic showed that the yield of VCE in the obscure-overt group (60%) was significantly higher than in the obscure-occult group (46%). For the OGIB patients overall, after VCE there was significant reduction in hospitalizations, additional investigations, and units of blood transfused compared with before VCE [11].

Several prospective studies and a meta analysis [12] have compared VCE with push enteroscopy in the evaluation of patients with OGIB. They have shown a significantly better yield for VCE (63%) compared with push enteroscopy (23%). In a recent randomized study, VCE and push-enteroscopy were used for first-line exploration of OGIB and identified a bleeding source in 50% vs. 24%, of patients, respectively (P = 0.02) [13]. Furthermore, in another study, it was shown that VCE detected a source of bleeding in a greater proportion of patients (72%), than computed tomography (CT) angiography (24%), or standard angiography (56%) and gave positive findings in more than half of the cases that were negative at computed tomography or angiography [14]. When compared with intraoperative endoscopy as reference, VCE had sensitivity, specificity and positive and negative predictive values of 95%, 75%, 95%, and 86% respectively [15].

Studies published to date have shown that the diagnostic yield for VCE is higher compared with that of double-balloon enteroscopy (DBE) [16–18]. In a US multicenter trial, the agreement between VCE and DBE was about 74% for angioectasias, 96% for ulcerations, 94% for mucosal and submucosal polyps, and 96% for large tumors [19]. Two studies investigated the yield and the outcomes of DBE following VCE in patients with OGIB. Patients first underwent VCE and then DBE. The overall detection rates for both techniques were similar. Therefore, these two techniques may be considered complementary [20, 21]. However, DBE may permit endoscopic treatment of the bleeding lesion [21].

VCE is a cost-effective investigation in patients with OGIB. The diagnostic yield of VCE compared with other imaging procedures has been evaluated as a measure of efficacy. The mean cost of a positive diagnosis with VCE was 2091€ and that of other procedures was 3829€ with a mean cost saving of 1738€ for one positive diagnosis [21].

Iron-deficiency anemia

VCE is a useful examination for investigating potential small-bowel causes of iron deficiency anemia (IDA). A study recruited 51 patients to undergo capsule endoscopy for unexplained IDA following a negative work-up and exclusion of other causes of anemia. Capsule endoscopy identified a likely source of IDA in 57%, while enteroclysis revealed abnormal findings likely to be causing IDA in only 11.8% of the patients (P < 0.0001) [22].

Nonstricturing small-bowel Crohn's disease

VCE has a high diagnostic yield for small-bowel lesions of Crohn's disease in patients with suspected as well as established disease. The main reasons for a VCE procedure in Crohn's disease are to establish the diagnosis, to assess disease prognosis, disease activity, and mucosal healing post therapy, and to define the extent and severity of disease. VCE examination may be particularly important before medication dosage is changed, and for follow-up after immunomodulators and biologics have been given. VCE may permit confirmation of the diagnosis when Crohn's disease is suspected on clinical grounds, without a definite diagnosis from another modality.

A recent meta-analysis summarized the diagnostic yield of VCE for this disease in comparison with all the other available procedures [23]. For all the patients examined, significant incremental diagnostic yields were found as follows: small-bowel follow-through 40% (9 studies); colonoscopy and ileoscopy 15% (4 studies); CT enterography 38% (3 studies); push enteroscopy 38% (2 studies); and magnetic resonance imaging (MRI) 22% (1 study) [23]. There was no significant difference seen between VCE and alternate modalities for diagnosing small-bowel Crohn's disease in patients with a suspected initial presentation, but a trend towards significance suggests the possibility of type II error. Subgroup analysis of patients with established disease and suspected small-bowel recurrence revealed a statistically significant difference in diagnostic yield in favor of VCE compared with all the modalities mentioned. In a small prospective study in known or suspected Crohn's disease, the sensitivity of VCE for active small-bowel Crohn's disease was not significantly different from computed tomography, ileocolonoscopy or even small-bowel follow-through [60]. However, it was concluded that lower specificity and the need for preceding radiography due to the high frequency of retention may limit its use as a first-line test. VCE was found to be more effective than colonoscopy and intubation of the neoileum after surgery for Crohn's disease [61]. Out of 24 patients prospectively studied, recurrence was demonstrated in 15 (62%) with the VCE and only in 6 (25%) with colonoscopy. VCE should also be considered in ulcerative colitis patients with atypical clinical features, particularly after colectomy and in cases of indeterminate colitis [62].

The risk for VCE retention in Crohn's disease patients is estimated to be 5%–13% [24]. Thus, small-bowel follow-through, CT, or patency capsule examinations that exclude stricture should be performed first in suspected or established Crohn's disease [25].

Not all ulcers are Crohn's disease, and not all biopsies are confirmatory. Nonsteroidal anti-inflammatory drug intake, lymphoid hyperplasia, lymphoma, radiation enteritis, vasculitis, or infectious disease may cause similar lesions in the small bowel. Nonsteroidal anti-inflammatory drugs should be stopped 2 months prior to the test [26]. To overcome some of these obstacles a diagnostic index has been developed with a scoring system that enables estimation of small-bowel disease activity for clinical and investigational needs [63].

The importance of mucosal healing is now under intense scrutiny in the era of new investigational therapy for Crohn's disease. VCE is the only method, except for double-balloon enteroscopy, for accurate assessment of mucosal healing. However a prospective study comparing clinical response to therapy and evidence for mucosal healing as found at VCE could not establish a significant correlation between them [64]. Recently, the advent of double-balloon enteroscopy has provided a "gold-standard" modality for assessing the diagnostic yield of VCE. Outcome studies with a long follow-up after VCE procedures are still needed. A small, prospective study of 27 patients suspected to have Crohn's disease, revealed a sensitivity of 93 % and specificity of 84 % for the VCE examination, and demonstrated a significant change in their management [65].

Celiac disease

VCE may be a useful tool for the diagnosis of celiac disease, because it is noninvasive, it images the entire length of the small bowel and is able to detect minute mucosal details including changes in intestinal villi.

Suspected celiac disease. Two studies in patients with suspected celiac disease and positive celiac serology [27,28] compared the diagnostic performance of VCE with that of conventional upper gastrointestinal endoscopy with duodenal biopsies. Using duodenal histology as the gold standard, both studies showed that VCE had good sensitivity (85.0 %–87.5 %) and specificity (100 %–90.9 %) for the diagnosis of celiac disease. In a more recent study [29] carried out in untreated patients with biopsy-proven celiac disease, VCE had 92 % sensitivity and 100 % specificity for the detection of villous atrophy.

Refractory or complicated celiac disease. In a study of 47 patients with complicated celiac disease [30], VCE had a high diagnostic yield, by identifying mucosal abnormalities and by excluding adenocarcinoma. In another study of 14 patients with refractory celiac disease [31], VCE identified signs of ulcerative jejunoileitis or intestinal T-cell lymphoma in 2/7 patients with type II refractory celiac disease. In one of these, the diagnosis could be made by VCE only.

Hereditary polyposis syndromes

A small series showed that VCE is more effective than barium contrast studies in detecting small-bowel polyps in patients with familial adenomatous polyposis (FAP) or Peutz–Jeghers syndrome (PJS) [32]. Its accuracy has been shown to equal to that of MRI for detecting small-bowel polyps bigger than 15 mm, but the detection rate for polyps 5–15 mm in size was much higher for VCE and polyps smaller of 5 mm were visualized only by VCE; however, it provided only partial views of large polyps, while MRI provide a better estimation of the site and the size of the detected polyps [33]. Available published data suggest that now VCE may replace enteroclysis for surveillance in PJS patients [34,35].

VCE is indicated in FAP patients with duodenal polyps, because these patients may develop small-bowel polyps [34–36]. Although VCE allows better visualization of the small bowel than other noninvasive diagnostic methods, it has low sensitivity for identifying the major papilla and does not seem accurate in distinguishing the ampullary from the periampullary region [35–38]. Therefore, the use of side-view duodenoscopy for staging duodenal disease is mandatory. Few comparative data are available for VCE versus enteroscopy in the setting of FAP [66].

Small-bowel tumors

Following the introduction of VCE in clinical practice, it was shown that the frequency of small-bowel tumors is higher than previously published (2 %), ranging from 2.4 % to 9.6 % in patients who underwent VCE for a variety of indications [39,40,67–71]. In patients with small-bowel tumors the usual clinical indication for VCE examination is obscure gastrointestinal bleeding (OGIB) in about 70 %–90 % of cases [39,40,67,68].

The majority of tumors identified by VCE are adenocarcinomas, followed by carcinoids, lymphomas, sarcomas and hamartomas [39,67,68,70]. Gastrointestinal stromal tumors (GISTs) are the most frequent benign neoplasm, accounting for about 32 % of all cases [40]. Other benign neoplasms include inflammatory polyps, lymphangiomas, lymphangioectasias, hemangiomas, hamartomas, adenomas, and lipomas. Melanoma is the most common tumor metastasizing to the small bowel [72], but metastases derived from colorectal cancer and hepatocellular carcinoma have also been reported [40,68,71]. Tumors are located in the jejunum (40 %–60 %), the ileum (25 %–40 %), and less frequently in the duodenum (15 %–20 %).

The diagnosis of small-bowel tumors has often been delayed when traditional techniques are used. The majority of patients with small-bowel tumors usually undergo multiple investigations prior to VCE without any definitive diagnosis. The average work-up prior to VCE has been reported to range between 3.6 and 5 previous negative procedures per patient [39,69,71]. VCE provides a satisfactory estimation of tumor location compared with surgery or autopsy [40,71] and it seems to influence the therapeutic work-up, providing information on the location, dimension, and appearance of the lesion [39,40].

Limitations and risks
▼

Small-bowel VCE has a few limitations and risks, of which those practicing VCE examination should be aware. MRI examination, if needed, should not be done before the capsule is expelled from the gastrointestinal tract. VCE should also not be used in patients with swallowing disorders, due to the risk of aspiration. Pregnancy is regarded as a contraindication for VCE examination because of the microwaves transmitted by the capsule. However, there are two case reports of VCE examination during the first trimester of pregnancy [73,74]. Capsule retention in the stomach and known or suspected small-bowel strictures are discussed in other sections. VCE is not contraindicated in patients with a cardiac pacemaker [75] or implantable cardiac defibrillator [76] and there is no interference between the two devices.

Esophageal video capsule endoscopy
▼

In 2004, Given Imaging developed an esophageal video capsule (PillCam ESO) as a noninvasive device for the examination of the esophagus. The capsule was similar in size as the intestinal capsule, but was equipped with two optical domes, allowing the capture of 14 images/second, 7 from each side [2]. The operating time was 20 minutes. A new version was released by Given Imaging in 2007, the PillCam ESO 2 [77], with an almost doubled field-of-view, a 50 % increase in depth-of-view, a frame rate of 15 frames/second, better image quality and a wide dynamic range, and illumination adjusted in real time to provide optimal images. A specific ingestion protocol is required to slow down the

transit of the capsule along the esophagus and increase the duration of examination of the esophageal mucosa. The patient lies on their right side and following ingestion of the capsule swallows sips of water every 15 seconds over 3 minutes [78].

The main indications for esophageal VCE are screening of Barrett's esophagus and of esophageal varices. Since 2006, the accuracy of esophageal VCE for detecting lesions related to gastroesophageal reflux has been evaluated in several studies comparing the diagnostic yield of VCE and esophagogastroduodenoscopy (EGD) [41,42,79,80]. In these studies, esophageal VCE appeared feasible, safe, well tolerated, and always preferred by patients to unsedated EGD. However, the sensitivity of esophageal VCE was quite variable between studies, ranging from 60% to 100% for Barrett's esophagus and from 50% to 89% for erosive esophagitis. In addition, in a recent study, a quite low diagnostic agreement was found between esophageal VCE and EGD in a heterogeneous series of patients undergoing EGD because of suspicion of various esophageal diseases [43].

A large, multicenter prospective study compared EGD and esophageal VCE for the detection of esophageal varices [81], and showed very good positive and negative predictive values (92% and 77%, respectively) and an overall fair agreement with EGD (kappa 0.73). Moreover, in discriminating between medium/large varices requiring treatment and small/absent varices requiring surveillance, the positive and negative predictive values for VCE were 87% and 92%, respectively, with a substantial overall agreement of 91% (kappa 0.77) on treatment decisions based on variceal size. Two recent studies have compared the cost-effectiveness of esophageal VCE versus EGD and/or systematic prescription of prophylaxis by beta-blocking agents [82,83]. None of these studies demonstrated superiority of esophageal VCE over the other approaches.

Both in the screening of Barrett's esophagus and of esophageal varices, the usefulness of esophageal VCE must be weighed against the wide availability of EGD, its good tolerability and relatively low cost. Moreover, EGD allows a complete examination of the stomach and duodenum during the same procedure and biopsy sampling.

Video capsule endoscopy of the colon
▼

The PillCam Colon capsule (Given Imaging) has recently been launched on the market. The device has some technical differences from the small-bowel capsule: it is approximately 6 mm longer; it has dual cameras that enable the device to acquire video images from both ends, optics with more than twice the coverage area of the small-bowel capsule; automatic light control; and a frame rate of four frames per second. After initial capsule activation and 5 minutes of image transmission, the capsule enters a delay mode of approximately 2 hours, after which it spontaneously "wakes up" and restarts the transmission of images for approximately 10 hours. [3,84]. The recommended preparation regimen consists of conventional colonoscopy preparation plus ingestion of domperidone before capsule ingestion, and boosts of sodium phosphate purge and bisacodyl suppositories during the examination [3,84,85].

This noninvasive examination has been evaluated in two pilot studies [3,84], in one large European trial [85], and in a meta-analysis [86] as an alternative modality for colon neoplasia screening. Data from these studies suggest that the colon capsule is expelled within 10 hours post ingestion in from 74% of patients [3] to more than 90% [85], allowing therefore the examination of the entire colon in the majority of patients. However, bowel cleansing is an issue. In the two pilot studies there was poor bowel preparation in 1%–3% of cases [3,84], but in the large European trial the proportion of cases with fair/poor bowel preparation was 29% [85]. No examination-related adverse events have been reported to date [3,84,85]. According to the meta-analysis [86], the sensitivity and specificity of colon VCE for the detection of significant colon adenomas and carcinomas are 69% and 86%, respectively, suggesting that although it is a promising tool, colon VCE needs improvement before it can be an alternative to colonoscopy for colon cancer screening.

Colon VCE might also have potential first as a complement to incomplete colonoscopy, and secondly where conventional colonoscopy is either refused by patients or poses substantial risk to them. A small case series did not show encouraging results for the first proposition [87], and there are no published data regarding the second.

Competing interests: None

Institutions
[1] 1st and 2nd Departments of Internal Medicine-Propaedeutic, Medical School, University of Athens, Athens, Greece
[2] Digestive Endoscopy Unit, Università Cattolica del Sacro Cuore, A. Gemelli University Hospital, Rome, Italy
[3] Institut Arnault Tzanck, Lyon, France
[4] Department of Gastroenterology, Rabin Medical Center, Tel Aviv University, Israel
[5] Department of Internal Medicine and Digestive Pathology, Hopitaux de Brabois, University Hospital of Nancy, France
[6] Department of Medical Sciences, University of Milan, Fondazione Ospedale IRCCS Maggiore Policlinico, Mangiagalli and Regina Elena, Milan, Italy

References
1 *Phillips B, Ball C, Sackett D et al.* Oxford Centre for Evidence-Based Medicine. Levels of evidence. May 2001 Accessed 28 February 2009: www.cebm.net/levels_of_evidence.asp
2 *Eliakim R, Yassin K, Shlomi I et al.* A novel diagnostic tool for detecting oesophageal pathology: the PillCam oesophageal video capsule. Aliment Pharmacol Ther 2004; 20: 1083–1089
3 *Eliakim R, Fireman Z, Gralnek IM et al.* Evaluation of the PillCam Colon capsule in the detection of colonic pathology: results of the first multicenter, prospective, comparative study. Endoscopy 2006; 38: 963–970
4 *Rey JF, Ladas S, Alhassani A, Kuznetsov K ESGE Guidelines Committee European Society of Gastrointestinal Endoscopy (ESGE).* Video capsule endoscopy: update to guidelines (May 2006). Endoscopy 2006; 38: 1047–1053
5 *Liao Z, Li ZS, Xu C.* Reduction of capture rate in the stomach increases the complete examination rate of capsule endoscopy: a prospective randomized controlled trial. Gastrointest Endosc 2009; 69: 418–425
6 *Rokkas T, Papaxoinis K, Triantafyllou K et al.* Does purgative preparation increase the diagnostic yield of small bowel video capsule endoscopy? A meta-analysis. Am J Gastroenterol 2009; 104: 219–227
7 *Niv Y.* Efficiency of bowel preparation for capsule endoscopy examination: a meta-analysis. World J Gastroenterol 2008; 14: 1313–1317
8 *Marmo R, Spada C, Rotondano G et al.* Efficacy of small bowel preparation to improve capsule endoscopy outcomes: a systematic review. Endoscopy 2008; 40 Suppl 1: A309
9 *Apostolopoulos P, Liatsos C, Gralnek IM et al.* Evaluation of capsule endoscopy in active, mild-to-moderate, overt GI bleeding. Gastrointest Endosc 2007; 66: 1174–1181
10 *Lai LH, Wong GI, Chow DK et al.* Long term follow-up of patients with obscure gastrointestinal bleeding after negative capsule endoscopy. Am J Gastroenterol 2006; 101: 1224–1228
11 *Carey EJ, Leighton JA, Heigh RI et al.* A single-center experience of 260 consecutive patients undergoing capsule endoscopy for obscure gastrointestinal bleeding. Am J Gastroenterol 2007; 102: 89–95

12 *Triester SL, Leighton JA, Leontiadis GI et al.* A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with obscure gastrointestinal bleeding. Am J Gastroenterol 2005; 100: 2407 – 2418

13 *de Leusse A, Vahedi K, Edery J et al.* Capsule endoscopy or push enteroscopy for first-line exploration of obscure gastrointestinal bleeding? Gastroenterology 2007; 132: 855 – 862

14 *Saperas E, Dot J, Videla S et al.* Capsule endoscopy versus computed tomographic or standard angiography for the diagnosis of obscure gastrointestinal bleeding. Am J Gastroenterol 2007; 102: 731 – 737

15 *Hartmann D, Schmidt H, Bolz G et al.* A prospective two-center study comparing wireless capsule endoscopy with intraoperative enteroscopy in patients with obscure GI bleeding. Gastrointest Endosc 2005; 61: 826 – 832

16 *Mehdizadeh S, Ross A, Gerson L et al.* What is the learning curve associated with double balloon enteroscopy? Technical details and early experience in 6 U.S. tertiary care centers. Gastrointest Endosc 2006; 64: 740 – 750

17 *Hadithi M, Heine GD, Jacobs MA et al.* A prospective study comparing video capsule endoscopy with double balloon enteroscopy in patients with obscure gastrointestinal bleeding. Am J Gastroenterol 2006; 101: 52 – 57

18 *Nakamura M, Niwa Y, Ohmiya N et al.* Preliminary comparison of capsule endoscopy and double-balloon enteroscopy in patients with suspected small-bowel bleeding. Endoscopy 2006; 38: 59 – 66

19 *Kamalaporn P, Cho S, Basset N et al.* Double-balloon enteroscopy following capsule endoscopy in the management of obscure gastrointestinal bleeding: outcome of a combined approach. Can J Gastroenterol 2008; 22: 491 – 495

20 *Kameda N, Higuchi K, Shiba M et al.* A prospective, single-blind trial comparing wireless capsule endoscopy and double-balloon enteroscopy in patients with obscure gastrointestinal bleeding. J Gastroenterol 2008; 43: 434 – 440

21 *Marmo R, Rotondano G, Rondonotti E et al.* Capsule enteroscopy vs other diagnostic procedures in diagnosing obscure gastrointestinal bleeding: a cost-effectiveness study. Eur J Gastroenterol Hepatol 2007; 19: 535 – 542

22 *Apostolopoulos P, Liatsos C, Gralnek IM et al.* The role of wireless capsule endoscopy in investigating unexplained iron deficiency anemia after negative endoscopic evaluation of the upper and lower gastrointestinal tract. Endoscopy 2006; 38: 1127 – 1132

23 *Triester SL, Leighton JA, Leontiadis GI 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

24 *Cheifetz AS, Korenbluth AA, Legnani P 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

25 *Banerjee R, Bhargav P, Reddy P et al.* Safety and efficacy of the M2A patency capsule for diagnosis of critical intestinal patency: results of a prospective clinical study. J Gastroenterol Hepatol 2007; 22: 2060 – 2063

26 *Graham DY, Opekun AR, Willingham FF et al.* Visible small-intestinal mucosal injury in chronic NSAID users. Clin Gastroenterol Hepatol 2005; 3: 55 – 59

27 *Hopper AD, Sidhu R, Hurlstone DP et al.* Capsule endoscopy: an alternative to duodenal biopsy for the recognition of villous atrophy in coeliac disease? Dig Liv Dis 2007; 39: 140 – 145. Epub 2006 Sep 11

28 *Rondonotti E, Spada C, Cave D et al.* Video capsule enteroscopy in the diagnosis of celiac disease: a multicenter study. Am J Gastroenterol 2007; 102: 1624 – 1631

29 *Murray JA, Rubio-Tapia A, VanDyke CT et al.* Mucosal atrophy in celiac disease: extent of involvement, correlation with clinical presentation and response to treatment. Clin Gastroenterol Hepatol 2008; 6: 186 – 193

30 *Culliford A, Daly J, Diamond B et al.* The value of wireless capsule endoscopy in patients with complicated celiac disease. Gastrointest Endosc 2005; 62: 55 – 61

31 *Daum S, Wahnschaffe U, Glasenapp R et al.* Capsule endoscopy in refractory celiac disease. Endoscopy 2007; 39: 455 – 458

32 *Mata A, Llach J, Castells A et al.* A prospective trial comparing wireless capsule endoscopy and barium contrast series for small-bowel surveillance in hereditary GI polyposis syndromes. Gastrointest Endosc 2005; 61: 721 – 725

33 *Caspari R, von Falkenhausen M, Krautmacher C et al.* Comparison of capsule endoscopy and magnetic resonance imaging for the detection of polyps of the small intestine in patients with familial adenomatous polyposis or with Peutz–Jeghers' syndrome. Endoscopy 2004; 36: 1054 – 1059

34 *Burke CA, Santisi J, Church J et al.* The utility of capsule endoscopy small bowel surveillance in patients with polyposis. Am J Gastroenterol 2005; 100: 1498 – 1502

35 *Schulmann K, Hollerbach S, Kraus K et al.* Feasibility and diagnostic utility of video capsule endoscopy for the detection of small bowel polyps in patients with hereditary polyposis syndromes. Am J Gastroenterol 2005; 100: 27 – 37

36 *Iaquinto G, Fornasarig M, Quaia M et al.* Capsule endoscopy is useful and safe for small-bowel surveillance in familial adenomatous polyposis. Gastrointest Endosc 2008; 67: 61 – 67

37 *Clarke JO, Giday SA, Magno P et al.* How good is capsule endoscopy for detection of periampullary lesions? Results of a tertiary-referral center. Gastrointest Endosc 2008; 68: 267 – 272

38 *Wong RF, Tuteja AK, Haslem DS et al.* Video capsule endoscopy compared with standard endoscopy for the evaluation of small-bowel polyps in persons with familial adenomatous polyposis (with video). Gastrointest Endosc 2006; 64: 530 – 537

39 *Urbain D, De Looze D, Demedts I et al.* Video capsule endoscopy in small-bowel malignancy: a multicenter Belgian study. Endoscopy 2006; 38: 408 – 411

40 *Rondonotti E, Pennazio M, Toth E et al.* Small-bowel neoplasms in patients undergoing video capsule endoscopy: a multicenter European study. Endoscopy 2008; 40: 488 – 495

41 *Sharma P, Wani S, Rastogi A et al.* The diagnostic accuracy of esophageal capsule endoscopy in patients with gastroesophageal reflux disease and Barrett's esophagus: A blinded prospective study. Am J Gastroenterol 2007; 102: 1 – 8

42 *Galmiche JP, Sacher-Huvelin S, Coron E et al.* Screening for esophagitis and Barrett's esophagus with wireless esophageal capsule endoscopy. A multicenter prospective trial in patients with reflux symptoms and/or dyspepsia. Am J Gastroenterol 2008; 103: 538 – 45

43 *Delvaux M, Papanikolaou IS, Fassler I et al.* Esophageal capsule endoscopy in patients with suspected esophageal disease: double blinded comparison with esophagogastroduodenoscopy and assessment of interobserver variability. Endoscopy 2008; 40: 16 – 22

44 *Bang S, Park JY, Jeong S 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

45 *Cave DR, Fleischer DE, Leighton JA et al.* A multicenter randomized comparison of the Endocapsule and the Pillcam SB. Gastrointest Endosc 2008; 68: 487 – 494

46 *Hartmann D, Eickhoff A, Damian U et al.* Diagnosis of small-bowel pathology using paired capsule endoscopy with two different devices: a randomized study. Endoscopy 2007; 39: 1041 – 1045

47 *Gheorghe C, Iacob R, Bancila I.* Olympus capsule endoscopy for small bowel examination. J Gastrointest Liver Dis 2007; 16: 309 – 313

48 *Li CY, Zhang BL, Chen CX et al.* OMOM capsule endoscopy in diagnosis of small bowel disease. J Zhejiang Univ Sci B 2008; 9: 857 – 862

49 *Herrerias JM, Leighton JA, Costamagna G et al.* Agile patency system eliminates risk of capsule retention in patients with known intestinal strictures who undergo capsule endoscopy. Gastrointest Endosc 2008; 67: 902 – 909

50 *Postgate AJ, Burling D, Gupta A et al.* Safety, reliability and limitations of the given patency capsule in patients at risk of capsule retention: a 3-year technical review. Dig Dis Sci 2008; 53: 2732 – 2738

51 *Shiotani A, Opekun AR, Graham DY.* Visualization of the small intestine using capsule endoscopy in human subjects. Dig Dis Sci 2007; 52: 1019 – 1025

52 *Triantafyllou K, Kalli T, Ladas SD.* Small bowel purge after the entrance of the capsule in the duodenum results to better quality of bowel preparation for video-capsule endoscopy. Prospective, randomized, double-blind, placebo-controlled, real time viewer assisted study. Gastrointest Endosc 2008; 134 (Suppl 1): A339

53 *Ge ZZ, Chen HY, Gao YJ et al.* The role of simeticone in small-bowel preparation for capsule endoscopy. Endoscopy 2006; 38: 836 – 840

54 *Mergener K, Ponchon T, Gralnek I 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

55 *Ben-Soussan E, Savoye G, Antonietti M et al.* Factors that affect gastric passage of video capsule. Gastrointest Endosc 2005; 62: 785–790

56 *Westerhof J, Weersma RK, Koornstra JJ.* Risk factors for incomplete small-bowel capsule endoscopy. Gastrointest Endosc 2009; 69: 74–80

57 *Triantafyllou K, Kalantzis C, Papadopoulos AA et al.* Video-capsule endoscopy gastric and small bowel transit time and completeness of the examination in patients with diabetes mellitus. Dig Liv Dis 2007; 39: 575–580

58 *Papadopoulos AA, Triantafyllou K, Kalantzis C et al.* Effects of ageing on small bowel video capsule endoscopy examinations. Am J Gastroenterol 2008; 103: 1–7

59 *Lai LH, Wong GLH, Lau JYW.* Initial experience of real-time capsule endoscopy in monitoring progress of the video capsule through the upper GI tract. Gastrointest Endosc 2007; 66: 1211–1214

60 *Solem CA, Loftus EV Jr, Fletcher JG et al.* Small-bowel imaging in Crohn's disease: a prospective, blinded, 4-way comparison trial. Gastrointest Endosc 2008; 68: 255–266

61 *Pons Beltran, V, Nos P, Bastida G et al.* Evaluation of postsurgical recurrence in Crohn's disease: a new indication for capsule endoscopy. Gastrointest Endosc 2007; 66: 533–540

62 *Mehdizadeh S, Chen G, Enayati PJ et al.* Diagnostic yield of capsule endoscopy in ulcerative colitis and inflammatory bowel disease of unspecific type. Endoscopy 2008; 40: 30–35

63 *Gal E, Geller A, Fraser G et al.* Assessment and validation of the new capsule endoscopy Crohn's disease activity index. Dig Dis Sci 2008; 53: 1933–1937

64 *Efthymiou A, Viazis N, Mantzaris G et al.* Does clinical response correlate with mucosal healing in patients with Crohn's disease of the small bowel? A prospective, case-sensitive study using wireless capsule endoscopy. Inflamm Bowel Dis 2008; 14: 1542–1547

65 *Girelli CM, Porta P, Malacrida V et al.* Clinical outcome of patients examined by capsule endoscopy for suspected small bowel Crohn's disease. Dig Liv Dis 2007; 39: 148–154

66 *Matsumoto T, Esaki M, Moriyama T et al.* Comparison of capsule endoscopy and enteroscopy with the double-balloon method in patients with obscure bleeding and polyposis. Endoscopy 2005; 37: 827–832

67 *Cobrin GM, Pittman RH, Lewis BS.* Increased diagnostic yield of small bowel tumors with capsule endoscopy. Cancer 2006; 107: 22–27

68 *Bailey AA, Debinski HS, Appleyard MN et al.* Diagnosis and outcome of small bowel tumors found by capsule endoscopy: a three-center Australian experience. Am J Gastroenterol 2006; 101: 2237–2243

69 *Schwartz GD, Barkin JS.* Small-bowel tumors detected by wireless capsule endoscopy. Dig Dis Sci 2007; 52: 1026–1030

70 *Estevez E, Gonzalez-Conde B, Vazquez-Iglesias JL et al.* Incidence of tumoral pathology according to study using capsule endoscopy for patients with obscure gastrointestinal bleeding. Surg Endosc 2007; 21: 1776–1780

71 *Spada C, Riccioni ME, Familiari P et al.* Video capsule endoscopy in small-bowel tumours: a single centre experience. Scand J Gastroenterol 2008; 43: 497–505

72 *Prakoso E, Selby WS.* Capsule endoscopy in patients with malignant melanoma. Am J Gastroenterol 2007; 102: 1204–1208

73 *Hogan RB, Ahmad N, Hogan RB 3rd et al.* Video capsule endoscopy detection of jejunal carcinoid in life-threatening hemorrhage, first trimester pregnancy. Gastrointest Endosc 2007; 66: 205–207

74 *Wax JR, Pinette MG, Cartin A et al.* Cavernous transformation of the portal vein complicating pregnancy. Obstet Gynecol 2006; 108: 782–784

75 *Bandorski D, Irnich W, Brück M et al.* Capsule endoscopy and cardiac pacemakers: investigation for possible interference. Endoscopy 2008; 40: 36–39

76 *Leighton JA, Srivathsan K, Carey EJ et al.* Safety of wireless capsule endoscopy in patients with implantable cardiac defibrillators. Am J Gastroenterol 2005; 100: 1728–1731

77 *Gralnek IM, Adler SN, Yassin K et al.* Detecting esophageal disease with second-generation capsule endoscopy: initial evaluation of the PillCam ESO 2. Endoscopy 2008; 40: 275–279

78 *Gralnek IM, Rabinovitz R, Afik D et al.* A simplified ingestion procedure for esophageal capsule endoscopy: initial evaluation in healthy volunteers. Endoscopy 2006; 38: 913–918

79 *Koslowsky B, Jacob H, Eliakim R et al.* PillCam ESO in esophageal studies: improved diagnostic yield of 14 frames per second (fps) compared with 4 fps. Endoscopy 2006; 38: 27–30

80 *Lin OS, Schembre DB, Mergener K et al.* Blinded comparison of esophageal capsule endoscopy versus conventional endoscopy for a diagnosis of Barrett's esophagus in patients with chronic gastroesophageal reflux. Gastrointest Endosc 2007; 65: 577–583

81 *de Franchis R, Eisen GM, Laine L et al.* Esophageal capsule endoscopy for screening and surveillance of esophageal varices in patients with portal hypertension. Hepatology 2008; 47: 1595–1603

82 *Spiegel BM, Esrailian E, Eisen G.* The budget impact of endoscopic screening for esophageal varices in cirrhosis. Gastrointest Endosc 2007; 66: 679–692

83 *Stipho S, Das A, Sharma VK et al.* Cost effectiveness of string capsule endoscopy for screening and surveillance of esophageal varices. Gastroenterology 2007; 132: A557

84 *Schoofs N, Deviere J, Van Gossum A.* PillCam Colon capsule endoscopy compared with colonoscopy for colorectal tumor diagnosis: a prospective pilot study. Endoscopy 2006; 38: 971–977

85 *Van Gossum A, Munoz-Navas M, Fernandez-Urien I et al.* Capsule endoscopy versus colonoscopy for the detection of polyps and cancer. N Engl J Med 2009 16; 361: 264–270

86 *Rokkas T, Papaxoinis K, Triantafyllou K, Ladas SD.* A meta-analysis evaluating the accuracy of colon capsule endoscopy in detecting colon polyps. Gastrointest Endosc 2010; (in press):

87 *Triantafyllou K, Tsimbouris P, Kalantzis C et al.* PillCam colon capsule endoscopy does not always complement incomplete colonoscopy. Gastrointest Endosc 2009; 69: 572–576