EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 11
Issue: 2
120-131
Year: 2024

THE APPLICATIONS OF CAPSULE ENDOSCOPY IN IRON DEFICIENCY ANEMIA AND VARIOUS OTHER GASTROINTESTINAL DISEASES

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DOI: https://doi.org/10.56716/4/4317

Article Received on 06/12/2023 **Article Revised on 26/12/2023** **Article Accepted on 16/01/2024**

ABSTRACT
Video capsule endoscopy (VCE) has been around for three decades. It has been recognized gradually in the community to diagnose small intestinal disorders; today, it has become the gold standard. This review summarizes the use of VCE in Iron deficiency anemia and new practical applications in and outside the small intestine. VCE is a non-invasive procedure to directly visualize the gastrointestinal (GI) tract using a small capsule-shaped camera that can swallow. Its initial intent was to examine the small bowel, a limitation of a conventional endoscope. It is used to explore the entire length of the GI tract. It requires a thorough bowel preparation and a specific device to view the images. It is an outpatient exam with an acceptable tolerance to the patients. There are several indications for its use, including iron deficiency anemia, obscure gastrointestinal bleeding, Inflammatory bowel disease including ulcerative colitis and Crohn's to detect extension and phenotype, hereditary polyposis, and celiac disease. Therapeutic options are not included and require an assisted enteroscopy if a lesion is detected. Using a dissolvable patency capsule lowers the risk of mechanical intestinal occlusion. The colon capsule technology is up-and-coming for colorectal cancer screening and managing inflammatory bowel diseases. It offers gastroenterologists a new device to investigate the upper and lower GI tract with good future potential. The advantages of VCE are that it does not require any sedation under anesthesia or special training. The videos can be shared with off-site consultants.

INTRODUCTION

The length of the GI tract from mouth to anus is about 30 feet long.[1] Two-thirds of it is the small intestine and is subject to pathologies such as malabsorption, ulcers, bleeding, strictures, inflammation, polyps, and cancer.[1] Examination of the GI tract can be performed by various modalities like radiological imaging, flexible fiber-optic endoscopy, and capsule endoscopy CE.[2] The Food and Drug Administration approved VCE in 2004 in the US.[3] The gold standard conventional endoscopy of the upper and lower GI tract can be uncomfortable for the patient, as it requires sedation and has adverse events such as bleeding and perforation.[2] VCE has rapidly been established as a first-line investigation for small bowel examination, particularly for indicating obscure gastrointestinal bleeding.[4] GI bleeding has accounted for more than 500,000 admissions yearly in the United States.[5]

Bleeding from the GI tract can contribute to developing iron deficiency anemia (IDA) among individuals without another obvious source of bleeding. Colonoscopy and esophagogastroduodenoscopy (EGD) identify the cause of blood loss in most patients with GI bleeding, but in 5% to 10% of cases, the source is in the small bowel.[6] The use of VCE after negative bidirectional endoscopy in patients with IDA is controversial. It can identify the source of bleeding with a broad spectrum of endoscopic pictures in unexplained IDAs. Studies have shown the overall diagnostic yield of VCE in patients with iron deficiency anemia to be between 41% and 65%.[7][8] Positive findings can lead to diagnosis and appropriate management, while negative results can provide high negative predictive value for rebleeding.[9] Capsule endoscopy is a safe procedure with a capsule retention risk of 1–2% being its only procedure-related complication.[10] The colon capsule is rapidly becoming an essential alternative diagnostic tool for the lower gastrointestinal tract. It is being offered to patients who refuse a traditional colonoscopy or, in some cases, an incomplete colonoscopy.[11] Few studies have shown promising results with sensitivity to picking up pathology of over 99% and reading time under 6 minutes.[2] There is a trend toward developing deep learning algorithms using artificial intelligence in the future.

DISCUSSION

Video capsule endoscopy overview

An important technological innovation has been emerging in the field of Gastrointestinal endoscopy. Small Intestinal bleeding remains an uncommon event in patients presenting with GI bleeding. The advances in diagnosing small bowel bleeding with deep enteroscopy radiographic imaging and small bowel capsule endoscopy (SBCE) have led to the diagnosis of many diseases in the small bowel beyond GI bleeding, and these techniques have improved to identify GI pathologies in most of the patients.[1][12] It has a high positive and negative predictive value that can lead to a medical management change anywhere from 37% to 87% of patients.[13] SBCE has been introduced in clinical practice for more than 20 years; nowadays, it has become an essential tool for studying the small intestine.[14]

VCE has a good safety profile, is minimally invasive, provides high-quality images without radiation exposure, and enables inspection throughout the small bowl with no discomfort to the patient.[14][15] VCE has become the initial diagnostic test for small bowel bleeding. One study showed that repeat VCE may be beneficial when the bleeding changes from occult to overt or there is a hemoglobin drop ≥4 g/dl.[16] Glycol prepares the small bowel, the critical factor for high diagnostic performance. Therefore, a 2L polyethylene glycol-based purge is administered a day before the procedure and is a widely used regimen.[17] Artificial intelligence (AI) algorithms can shorten the reading time for VCE study in the future, as AI has revolutionized medicine with deep machine learning algorithms.[18]

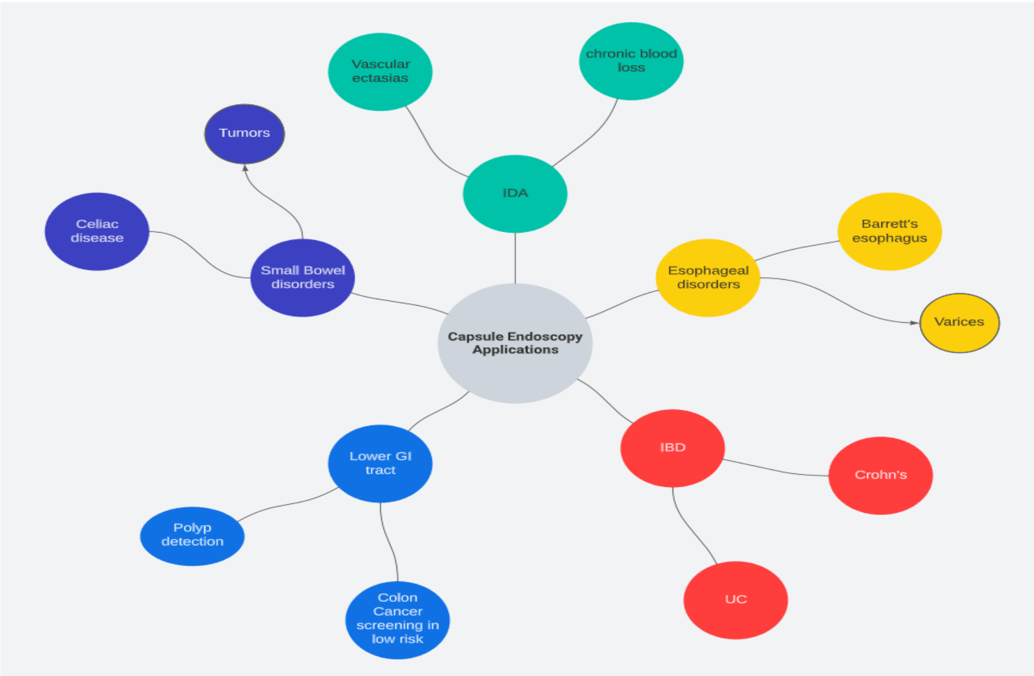

Figure 1: Application of capsule endoscopy.

Iron deficiency anemia

Anemia is blood Hb levels below 130g/L in men and 120g/L in women.[19] The most common cause of Anemia is IDA. It has been recognized as one of the most common nutritional deficiencies in the world by the world health organization, with 30% of the population affected.[20] The causes of IDA are GI bleeding, decreased dietary iron intake, diminished iron absorption, and menstruation in women.[21] IDA affects more than 1.2 billion people worldwide, and iron deficiency without anemia is more common.[22] A study of the global disease burden from 2016 identified IDA as the leading causes of years lived with disability(YLD) and is the first cause in women.[23] In developing countries, IDA is caused by poor iron intake or parasitic infection. In high-income countries, it is caused by poor absorption of iron, chronic blood loss, and adherence to a vegetarian diet. Oral iron can correct iron deficiency in most patients, but its side effects limit efficacy and compliance.[24]

IDA can be divided into two forms 1. absolute and 2. functional. Absolute IDA is defined as low total body iron caused by increased physiological iron requirements in pregnancy, young children, and adolescents, with reduced iron intake, deficiencies in absorption, or chronic blood loss.[24] Functional IDA is defined as ferritin greater than 200ng/mL with transferrin saturation of less than 20% and has adequate iron stores but without sufficient iron mobilization.[25] Globally, IDA has many social and medical impacts, accounting for cognitive impairment in young children, associated with adverse outcomes in pregnancy, decreased physical activity in adults, and decline in cognitive abilities in the elderly.[26][27] IDA is treated to replenish iron stores and return Hb to an average level; this has been shown to improve quality of life, prognosis, morbidity, and outcome in pregnancy. Replenishment of iron occurs via three routes: oral iron formulations, intravenous iron, and transfusion of packed red blood cells.[28]

Iron deficiency anemia in elderly

Iron deficiency anemia is one of the common diagnoses in the geriatric population, and the common etiology for hospitalized elderly is anemia of chronic disease or iron deficiency anemia.[29] In the United States, estimates show that in adults more significant than 65 years of age, 10% of women and 11% of men, and more than 20% at age 85 are anemic. The prevalence rate is about 60% in residential/nursing care.[30] In older populations, the workup for IDA requires potential causes and malignancy of the GI tract. There is an increased mortality risk in older adults, age greater than 85, with a hazard ratio of 1.41 (CI - 1.13 - 1.76).[31] Iron status and metabolism play a significant role in several conditions in older populations with increased ferritin levels or decreased Hb levels and can be associated with poor prognosis. The correction of iron status improves the disease prognosis, but it is crucial to diagnose IDA.[32]

Iron deficiency anemia in women

Iron deficiency and IDA are highly prevalent in women, especially during the reproductive years.[33] IDA in women can be caused by heavy menstrual bleeding, pregnancy, and postpartum.[33][34] It is associated with a significant number of adverse consequences in both the emotional and physical well-being of women.[22] There is a high prevalence of increased tiredness in young and middle-aged women.[35] IDA is common in patients with cardiovascular disease. There is an increased prevalence proportional to the severity of cardiac and renal diseases, which are more common among women.[36] Occult or gross bleeding from lesions in the GI tract is a common cause of IDA in men and postmenopausal women and a common cause of referral to GI.[37] Symptoms include fatigue, pica (ice craving), restless leg syndrome, poor concentration, and work function, increased susceptibility to infection, and cardiovascular stress-which can cause significant morbidity and reduced quality of life.[38]

In a study, it was found that older African American women (age >50) have higher rates of GI bleeding and tumors of the colon when compared with younger generations.[39] Clinical practice guidelines recommend VCE studies in patients with IDA after conventional upper and lower endoscopies. In a study with pre-and postmenopausal women with IDA, the most common findings were angiomatosis in postmenopausal and erosions in premenopausal.[40] The cause in premenopausal women is presumed to be loss of menstrual blood, but in a prospective study, 95% have significant upper GI disease even after ruling out a gynecological source.[41] This suggests carefully evaluating diagnostic procedures such as upper endoscopy and capsule endoscopy to identify the cause of IDA in women.

Iron deficiency anemia in Inflammatory bowel disease

Inflammatory bowel diseases (IBD)s like Crohn's disease (CD) and ulcerative colitis (UC) have increased incidence all around the world and have a significant impact on general well-being, social functioning, and utilization of healthcare resources.[42][43] Iron deficiency is among the leading cause of anemia in IBD, and diagnosis is complicated, as biochemical tests cannot distinguish between IDA and anemia of chronic disease.[44] IBD-associated anemia, particularly IDA, is associated with a significant decrease in the quality of life and includes other symptoms like fatigue, headaches and dizziness, reduced exercise tolerance, pale skin, nails, and conjunctiva.[45] VCE has become an essential procedure for many pathologies of small bowel (SB) diseases, including IBD,d will help to optimize the treatment strategy for CD patients.[46] The CD is diagnosed based on clinical symptoms and diagnostic modalities using endoscopic, radiological, histological, and biochemical studies.[47] As ileocolonoscopy with biopsy and imaging is the gold standard to confirm the diagnosis, 30% of patients were found to have CD beyond the reach of the ileocolonoscope, and VCE is particularly useful in these patients.[47] The European Society of Gastrointestinal Endoscopy (ESGE) suggests careful patient selection based on monitoring symptoms and fecal/serologic biomarkers to improve the accuracy and yield of VCE in patients with suspected CD.[48] The significant limitation of VCE in UC is the large volume of intestinal preparations required with a large volume of laxatives that the patient needs to ingest, reducing patients' acceptability and increasing the impossibility of taking biopsies.[49] In a recent multicenter study, comparison of VCE, ileocolonoscopy, and MRE, the sensitivity of the VCE was higher than MRE for proximal small bowel inflammation (97% vs. 71%, $p = 0.021$) and similar to MRE and ileocolonoscopy in the terminal ileum and colon, ($p = 0.500–0.625$).[50] The usefulness of the second-generation colon capsule endoscopy (CCE-2) and small bowel colon capsules is uncertain and large-scale studies are needed. Capsule retention is the most significant concern with performing VCE, particularly in CD. This event can be overcome by imaging using MRE and patent capsules before the procedure.[51]

IBD guidelines advocate the increased use of VCE to assess location and activity in patients with suspected or established CD.[52][53] Attention has shifted to the potential role of AI in the field of IBD; a future perspective is the creation of algorithms for diagnosing and monitoring IBD.[53] Takenaka et al. used large volumes of data to develop a deep neural network algorithm in AI for UC disease assessment, using 40,758 colonoscopy images and 6885 biopsy results from 2012 UC patients; the algorithm predicted endoscopic remission with 93% sensitivity and 88% specificity compared to the endoscopist.[54] The pooled accuracy of AI with VCE in CD for detecting ulcers or bleeding was

95.4% (sensitivity 95.5%, specificity 95.8%, PPV 95.8%, and NPV 96.8%), thus highlighting the potential of this innovation.[55] In the future, there will be a remarkable upgrade in the role of endoscopy in diagnosing IDA in UC and CD.[56]

Iron deficiency anemia in the presence of polyps (lower GI tract)

Roughly 10% of EGDs and colonoscopies are performed to evaluate IDA. No colorectal cancer screening guidelines exist for IDA investigation. Lower GI pathologies are more likely to cause IDA than upper GI.[57] Colorectal cancer is the third most prevalent and the fourth cause of death worldwide.[58] It causes a delay in diagnosis, hence the need for early screening to identify cancer, pre-cancerous polyps, and other abnormal disorders. There is an increase in the use of modalities such as VCE, enteroscopy, CT colonography, and colonoscopy. Colonoscopy is the standard modality for screening among the available methods for diagnosing colorectal disorders.[59] The CCE-2 is a new technology for diagnosing colon cancer; it is a non-invasive diagnostic method and does not require sedation or analgesia, with fast and accurate results for polyps and colon cancer.[60] The pooled sensitivity and specificity in the detection of polyps with a size >=6 mm was 84% and 88%; for polyps >= 10 mm, it was 84% and 96%; and for any size of polyp, it was 93% and 66% respectively.[60] This can reduce the need for participants to undergo a potentially unnecessary colonoscopy for patients with suspected low-risk polyps detected by CE, as the current screening for low-risk polyps indicate that most of these polyps may be incidental findings and not the cause of a positive FIT.[61] In addition to the low cost of capsules, the planned implementation of AI algorithms could reduce the costs of the diagnostic process, making CE more prevalent.[62]

VCE accuracy is nearly comparable to conventional colonoscopy for colorectal cancer and significant polyps. In an incomplete colonoscopy, VCE demonstrated higher diagnostic yield for significant polyps and to be better tolerated.[63] Adequate bowel preparation is essential in ensuring successful CCE results.[64] The main limitation of CCE is that it requires a more extensive bowel preparation than a colonoscopy or CT colonography because it requires laxatives for bowel cleansing and promoting capsule excretion.[65] CE accurately detects polyps and can increase patients' satisfaction and improve their quality of life and high negative predictive value. Despite its usefulness in polyp detection and colon cancer screening by identifying individuals who need a colonoscopy, it cannot biopsy or remove polyps that can be accomplished by colonoscopy.[61][66]

Diagnostic performance of capsule endoscopy

In a meta-analysis of 19 studies, the pooled sensitivity and specificity for CE to identify bleeding or a bleeding source are 96% and 99%, respectively.[67] The use of the Patency capsule to screen the patency of the GI tract before CE showed a pooled sensitivity of 97% and specificity of 83% from five studies(n=203).[68] In a comparison of magnetic resonance enteroclysis, computed tomography, CE, and push enteroscopy for obscure GI bleeding from 24 studies, CE has a higher sensitivity and lower specificity, with a better safety profile and few adverse reactions.[69] As esophageal variceal bleeding has a high mortality rate, CE provides a minimally invasive alternative to improve screening and surveillance with a diagnostic accuracy of 90%, pooled sensitivity of 83%, and specificity of 85% from 17 studies (n=1328).[70] For diagnosing oesophageal varices of any size in people with cirrhosis, the pooled sensitivity is 84.8%, and specificity is 84.3% (n=936); for large varices, with a higher risk of bleeding; the pooled sensitivity was 73.7% and specificity of 90.5%.[71] CE is preferred over esophagus-gastro-duodenoscopy reported in nine 10 studies.[71]

CE can be used to diagnose fecal calprotectin, a marker of colonic inflammation in Crohn's disease, with a sensitivity of 89 and specificity of 55 and a negative predictive value of 91.8%.[72] In a comparative study for the detection of endoscopic recurrence in postoperative Crohn's disease, between CE, magnetic resonance enterography (MRE), and intestinal ultrasound (US), CE had a higher pooled sensitivity of 100% and lower specificity of 69%. MRE has 97% sensitivity and 84% specificity; the US has 89% sensitivity and 86% specificity.[73] CE also has high sensitivity and specificity for colorectal cancer screening, with 85% and 85% for detecting polyps of any size, 87 % and 88% for polyps >=6mm, and 87% and 95% for polyps>=10mm, respectively.[74] CE is also used for the diagnosis of inflammatory bowel disease, with seven studies for Crohn's disease and 7 for ulcerative colitis (UC), in crohns CE is superior to MRE and colonoscopy with a pooled odds ratio of 1.25, and the diagnostic sensitivity for detecting UC is 94% and specificity is 70%.[75] CE has demonstrated high accuracy in detecting upper GI bleeding in emergency departments. From five studies that met the inclusion/exclusion criteria, the sensitivity was 72%, and the specificity of 75%.[76] Computer-aided diagnosis from 39 studies to report the diagnostic performance of GI ulcers and bleeding in CE has shown high performance for diagnosing GI ulcers and bleeding. The sensitivity and specificity for GI ulcers are 93% and 92%, and for GI bleeding or angioectasia, they are 96% and 97%, respectively.[77]

Table 1: Significance of VCE application.

S. No.	Study	Application	P value	Adverse events	Sample size
1	Yaling et al.[78]	Antiplatelet Therapy–Induced Gastrointestinal Injury	0.006	None	505
2	Milano et al[79]	Comparison of standard	<0.001	none	189

		endoscopy, video capsule endoscopy, and CT-enteroclysis in iron deficiency anemia			
3	Luj'an et al.[80]	Celiac disease	<0.001	one case of capsule retention	163
4	Freitas et al.[81]	Transit time in Small Bowel CE	0.001	prolonged transit time in 45	957
5	Baltes et al.[82]	Meckel's diverticulum	<0.05	None	69
6	Ching et al.[83]	magnetically assisted gastric CE Vs. Gastroscopy in recurrent and refractory iron deficiency anemia	<0.001	None	49
7	Ye et al.[84]	Correlation between CE and colonoscopy in Ulcerative colitis	<0.001	None	25
8	Tjandra et al.[85]	Correlation of colon CE with conventional colonoscopy in the terminal ileum	<0.001	None	34
9	Tjandra et al.[85]	Correlation of colon CE with traditional colonoscopy in the right colon	0.003	None	34
10	Tjandra et al[85]	Correlation of colon CE with conventional colonoscopy in the transverse colon	0.01	None	34
11	Tjandra et al.[85]	Correlation of colon CE with conventional colonoscopy in the left colon	0.109	None	34
12	Tjandra et al.[85]	Correlation of colon CE with conventional colonoscopy in rectum	0.617	None	34
13	Juan et al.[86]	Influence of Diet on CE transit time	0.3	None	21
14	Geropoulos et al.[87]	CE Versus Conventional Gastroscopy	<0.05	None	916
15	Wang et al.[88]	Declined rates of retention and SB incomplete examination over the past two decades	<0.0006	None	402
16	Zeng et al.[89]	Endoscopic images in the proximal third and middle third of the small bowel	0.007	frequent urination in a few cases	140
17	Marya et al.[90]	Early CE Vs. standard of care in non-hematemesis GI bleeding	<0.01	None	87
18	Jung et al.[91]	Fecal Calprotectin for Crohn's Disease	<0.05	None	4720
19	Xavier et al.[92]	Administration of Moviprep for SB preparation	0.002	None	101

The future direction of capsule endoscopy

Clinical applications are evident as artificial intelligence (AI) evolves rapidly in medicine.[93] GI has become an attractive field to apply and relies heavily on AI for endoscopic and radiologic imaging. AI has been used for rapid diagnosis, to reduce the rate of misdiagnosis, to improve imaging quality, and to interpret histopathology and radiology to detect GI neoplastic lesions.[94][95] AI has also become a potentially helpful tool for diagnosing VCE. In addition to detecting ulcers and polyps, deep learning algorithms were used to detect celiac disease, obscure bleeding, and hookworms. Most studies and conditions showed detection accuracy above 90%.[93] In a study with AI using VCE, there is a high diagnostic performance for detecting ulcers and erosions with sensitivity and specificity of 96% and 97%, GI bleeding with 97% and 100%, malignancy/cancer, and polyps with 97% and 98% respectively.[96] It is possible that CCE-2 could contribute to colorectal cancer (CRC) screening programs as a filter test between fecal immunochemical testing and standard colonoscopy.[100] Capsule enteroscopy is recommended to manage complicated celiac disease for both axial and lateral views to detect small bowel atrophy. It has good sensitivity and specificity when compared with histology.[97]

VCE can be used to identify polyps by deep learning algorithms and has a sensitivity of 97% and specificity of 97%, but this is mainly at the study stage and is not being used clinically in several applications due to a lack of training in large data volumes for performance and lack of prospective studies to prove reliability. Large-scale multicenter future randomized controlled studies are needed for the intelligent detection of polyps in colorectal screening.[98] VCE is used in managing celiac disease as both a diagnostic tool and to compile treatment plans with few complications; studies have shown that innovations such as AI-assisted endoscopy could significantly improve its efficiency and eliminate some of its disadvantages.[98][99] Parasitic infections represent another type of pathological entity that can be detected by this diagnostic method.[100] In a study of 11 patients, 440,000 images were used to develop a mechanism capable of automatically detecting these helminths in video-capsule images, with a sensitivity and specificity close to 78%.[91] The low numbers are due to distinguishing parasitic structures from bubbles and intestinal folds in the GI tract.[101] The automatic detection of this parasite remains a very challenging task; this task remains a critical proof of concept for AI.

Technology advancements will lead to newly upgraded capsules. AI will provide computing systems that can screen VCE videos, find possible lesions, and form a diagnosis in less time than today.[102] When this combination is introduced into everyday practice, the impact on endoscopy will be tremendous. It will be possible to investigate the whole GI tract accurately and promptly with just one capsule.[103]

Limitations

VCE had high sensitivity and specificity for detecting polyps compared to conventional colonoscopy. But due to the high rate of incomplete investigations, the application of CCE in a CRC screening is limited.[74] Although there is good diagnostic accuracy with VCE in Crohn's disease, more transmural assessment must be done. For UC, it has good positive predictive value and sensitivity, but the specificity is low and lacks d histologic assessment.[75] There is a potential advantage of VCE in the ED; further research is warranted to establish its role.[76]

There are a few barriers to achieving good diagnostic ability. To date, three main recurring themes extend across all studies: peristalsis, gastric preparation, and proximal stomach visualization.[104] Peristalsis, particularly in the antrum, restricts complete magnetic control over capsule endoscopy. This is the case when the capsule is rapidly expulsed into the pylorus and causes incomplete gastric examination or when the capsule is pushed back due to contractions.[105] Despite fasting, mucus, and residual gastric debris obscuring VCE views and interfering with mucosal assessment, there will be value in any upcoming studies to compare available gastric cleansing agents.[106] The visualization of the fundus and cardia compared to distal stomach counterparts is under-reported as the proximal stomach remains collapsed and has inadequate fundal views compared with gastroscopy, which provides distended views.[107]

CONCLUSION

VCE has been mounted in society guidelines as a first-line device for suspected small bowel bleeding. It is very promising for identifying IDA, celiac disease, colorectal cancer screening, and follow-up of inflammatory bowel diseases like ulcerative colitis and Crohn's. CCE is comparable to colonoscopy in a few clinical trials with good diagnostic sensitivity. However, it is still being assessed in high-risk patients in clinical practice and is becoming an alternative diagnostic tool for the lower GI tract. The limitation is the need for more significant bowel preparation compared to conventional colonoscopy. However, it is an attractive option to patients as it is painless and can be performed in an outpatient setting. A variety of small bowel hemorrhagic lesions detectable by VCE is robust and incorporates vascular and nonvascular lesions, solitary and systemic, benign, and malignant. CCE might become a routine initial diagnostic modality for lower-risk groups of patients, with conventional colonoscopy being reserved for cases where biopsy or therapy is necessary. This approach might reflect the ongoing efforts to make medical procedures less invasive and more patient-friendly, particularly for those who might not need extensive intervention. However, it has some limitations regarding therapeutic capability, as it cannot identify the precise location of the lesion and can provide false positive results. VCE is a safe and effective procedure for evaluating IDA in all young and older adults. Incorporating neural networks in the future might enhance lesion detection and can likely augment the role in small bowel bleeding. There is a need for more studies to compare the costs and efficacy between VCE and traditional endoscopy.

REFERENCES

1. Akpunonu B, Hummell J, Akpunonu JD, Ud Din S. Capsule endoscopy in gastrointestinal disease: Evaluation, diagnosis, and treatment. Cleve Clin J Med, 2022; 1 89(4): 200-211. doi: 10.3949/ccjm.89a.20061. PMID: 35365558.
2. Oka P, McAlindon M, Sidhu R. Capsule endoscopy - a non-invasive modality to investigate the GI tract: out with the old and in with the new? Expert Rev Gastroenterol Hepatol, 2022; 16(7): 591-599. doi: 10.1080/17474124.2022.2089113. Epub 2022 Jun 23. PMID: 35695266.
3. Park J, Cho YK, Kim JH. Current and future use of esophageal capsule endoscopy. Clin Endosc, 2018; 51(4): 317–322.
4. Wu RM, Fisher LR. Role of Video Capsule in Small Bowel Bleeding. Gastrointest Endosc Clin N Am, 2021; 31(2): 277-306. doi: 10.1016/j.giec.2020.12.003. PMID: 33743926.

5. Peery AF, Crockett SD, Barritt AS, Dellon ES, Eluri S, Gangarosa LM, Jensen ET, Lund JL, Pasricha S, Runge T, Schmidt M, Shaheen NJ, Sandler RS. Burden of Gastrointestinal, Liver, and Pancreatic Diseases in the United States. Gastroenterology, 2015; 149(7): 1731-1741.e3. doi: 10.1053/j.gastro.2015.08.045. Epub 2015 Aug 29. PMID: 26327134; PMCID: PMC4663148.
6. Peery AF, Crockett SD, Murphy CC, Jensen ET, Kim HP, Egberg MD, Lund JL, Moon AM, Pate V, Barnes EL, Schlusser CL, Baron TH, Shaheen NJ, Sandler RS. Burden and Cost of Gastrointestinal, Liver, and Pancreatic Diseases in the United States: Update 2021. Gastroenterology, 2022; 162(2): 621-644. doi: 10.1053/j.gastro.2021.10.017. Epub 2021 Oct 19. PMID: 34678215.
7. Milano A, Balatsinou C, Filippone A, et al. A prospective evaluation of iron deficiency anemia in the GI endoscopy: role of standard endoscopy, video capsule endoscopy, and CT-enteroclysis. Gastrointest Endosc, 2011; 73(5): 1002–1008.
8. Koulaouzidis A, Rondonotti E, Giannakou A, et al. Diagnostic yield of small-bowel capsule endoscopy in patients with iron-deficiency anemia: a systematic review. Gastrointest Endosc, 2012; 76(5): 983–992.
9. Khamplod S, Limsrivilai J, Kaosombatwattana U, Pausawasdi N, Charatcharoenwitthaya P, Pongprasobchai S, Leelakusolvong S. Negative Video Capsule Endoscopy Had a High Negative Predictive Value for Small Bowel Lesions. Still, Diagnostic Capability May Be Lower in Young Patients with Overt Bleeding. Can J Gastroenterol Hepatol, 2021; 7, 2021: 8825123. doi: 10.1155/2021/8825123. PMID: 34036087; PMCID: PMC8123999.
10. Rondonotti E. Capsule retention: prevention, diagnosis and management. Ann Transl Med, 2017; 5(9): 198. doi: 10.21037/atm.2017.03.15. PMID: 28567378; PMCID: PMC5438794.
11. Romero-Vázquez J, Argüelles-Arias F, García-Montes JM, Caunedo-Álvarez Á, Pellicer-Bautista FJ, Herrerías-Gutiérrez JM. Capsule endoscopy in patients refusing conventional endoscopy. World J Gastroenterol, 2014; 21, 20(23): 7424-33. doi: 10.3748/wjg.v20.i23.7424. PMID: 24966612; PMCID: PMC4064087.
12. Gerson LB, Fidler JL, Cave DR, Leighton JA. ACG Clinical Guideline: Diagnosis and Management of Small Bowel Bleeding. Am J Gastroenterol, 2015; 110(9): 1265-87; quiz 1288. doi: 10.1038/ajg.2015.246. Epub 2015 Aug 25. PMID: 26303132.
13. Tontini GE, Manfredi G, Orlando S, Neumann H, Vecchi M, Buscarini E, Elli L. Endoscopic ultrasonography and small-bowel endoscopy: Present and future. Dig Endosc, 2019; 31(6): 627-643. doi: 10.1111/den.13429. Epub 2019 Jun 12. PMID: 31090965.
14. Pennazio M, Rondonotti E, Pellicano R, Cortegoso Valdivia P. Small bowel capsule endoscopy: where do we stand after 20 years of clinical use? Minerva Gastroenterol (Torino), 2021; 67(1): 101-108. doi: 10.23736/S2724-5985.20.02745-2. Epub 2020 Jul 16. PMID: 32677419.
15. Yamamoto H, Aabakken L. Small-bowel endoscopy. Endoscopy, 2019; 51(5): 399-400. doi: 10.1055/a-0879-1823. Epub 2019 Apr 25. PMID: 31022761.
16. Chetcuti Zammit S, Sidhu R. Small bowel bleeding: cause and the role of endoscopy and medical therapy. Curr Opin Gastroenterol, 2018; 34(3): 165-174. doi: 10.1097/MOG.0000000000000429. PMID: 29521682.
17. Ben Soussan E, Antonietti M, Herve S et al. Diagnostic yield and therapeutic implications of capsule endoscopy in obscure gastrointestinal bleeding. Gastroenterol Clin Biol, 2004; 28: 1068–1073.
18. Koulaouzidis A, Rondonotti E, Karargyris A. Small-bowel capsule endoscopy: a ten-point contemporary review. World J Gastroenterol, 2013; 28, 19(24): 3726-46. doi: 10.3748/wjg.v19.i24.3726. PMID: 23840112; PMCID: PMC3699039.
19. Piccirelli S, Milluzzo SM, Bizzotto A, Cesaro P, Pecere S, Spada C. Small Bowel Capsule Endoscopy and artificial intelligence: First or second reader? Best Pract Res Clin Gastroenterol, 2021; 52-53: 101742. doi: 10.1016/j.bpg.2021.101742. Epub 2021 Mar 24. PMID: 34172256.
20. World Health Organisation. Hemoglobin concentrations for the diagnosis of anemia and assessment of severity. Vitamin and Mineral Nutrition Information System, 2011. https://www.who.int/vmnis/indicators/haemoglobin.pdf [Google Scholar]
21. Kumar A, Sharma E, Marley A, Samaan MA, Brookes MJ. Iron deficiency anemia: pathophysiology, assessment, practical management. BMJ Open Gastroenterol, 2022; 9(1): e000759. doi: 10.1136/bmjgast-2021-000759. PMID: 34996762; PMCID: PMC8744124.
22. NJ Kassebaum, R Jasrasaria, M Naghavi, et al. A systematic analysis of global anemia burden from 1990 to 2010 Blood, 2014; 123(5): 615-624.
23. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990-2016: a systematic analysis for the Global Burden of Disease Study, 2016; 390 (10100): 1211-1259.
24. Camaschella C. Iron deficiency: new insights into diagnosis and treatment. Hematology Am Soc Hematol Educ Program, 2015; 2015: 8-13. doi: 10.1182/asheducation-2015.1.8. PMID: 26637694.
25. Przybylowski P, Wasilewski G, Golabek K, Bachorzewska-Gajewska H, Dobrzycki S, Koc-Zorawska E, Malyszko J. Absolute and Functional Iron Deficiency Is a Common Finding in Patients With Heart Failure and After Heart Transplantation. Transplant Proc, 2016; 48(1): 173-6. doi:

10.1016/j.transproceed.2015.12.023. PMID: 26915864.
26. MM Achebe, A Gafter-Gvili How I treat anemia in pregnancy: iron, cobalamin, and folate Blood, 2017; 129(8): 940-949.
27. M Falkingham, A Abdelhamid, P Curtis, S Fairweather-Tait, L Dye, L Hooper The effects of oral iron supplementation on cognition in older children and adults: a systematic review and meta-analysis Nutr J, 2010; 9: 4.
28. Camaschella C. Iron deficiency. Blood, 2019; 3, 133(1): 30-39. doi: 10.1182/blood-2018-05-815944. Epub 2018 Nov 6. Erratum in: Blood, 2023 Feb 9; 141(6): 682. PMID: 30401704.
29. Helsen T, Joosten E. IJzergebreksanemie bij ouderen [Iron deficiency in the elderly]. Tijdschr Gerontol Geriatr, 2016; 47(3): 109-16. Dutch. doi: 10.1007/s12439-016-0171-7. PMID: 27106490.
30. Fairweather-Tait SJ, Wawer AA, Gillings R, Jennings A, Myint PK. Iron status in the elderly. Mech Ageing Dev, 2014; 136-137: 22-8. doi: 10.1016/j.mad.2013.11.005. Epub 2013 Nov 22. PMID: 24275120; PMCID: PMC4157323.
31. Lindblad AJ, Cotton C, Allan GM. Iron deficiency anemia in the elderly. Can Fam Physician, 2015; 61(2): 159. PMID: 25676647; PMCID: PMC4325864.
32. Wawer AA, Jennings A, Fairweather-Tait SJ. Iron status in the elderly: A review of recent evidence. Mech Ageing Dev, 2018; 175: 55-73. doi: 10.1016/j.mad.2018.07.003. Epub 2018 Jul 21. PMID: 30040993.
33. Petraglia F, Dolmans MM. Iron deficiency anemia: Impact on women's reproductive health. Fertil Steril, 2022; 118(4): 605-606. doi: 10.1016/j.fertnstert.2022.08.850. PMID: 36182259.
34. Mansour D, Hofmann A, Gemzell-Danielsson K. A Review of Clinical Guidelines on the Management of Iron Deficiency and Iron-Deficiency Anemia in Women with Heavy Menstrual Bleeding. Adv Ther, 2021; 38(1): 201-225. doi: 10.1007/s12325-020-01564-y. Epub 2020 Nov 27. PMID: 33247314; PMCID: PMC7695235.
35. Cappellini MD, Santini V, Braxs C, Shander A. Iron metabolism and iron deficiency anemia in women. Fertil Steril, 2022; 118(4): 607-614. doi: 10.1016/j.fertnstert.2022.08.014. Epub 2022 Sep 6. PMID: 36075747.
36. Cohen-Solal A, Damy T, Terbah M, Kerebel S, Baguet JP, Hanon O, et al.. High prevalence of iron deficiency in patients with acute decompensated heart failure. Eur J Heart Fail, 2014; 16: 984–991. [PubMed] [Google Scholar]
37. Khadem G, Scott IA, Klein K. Evaluation of iron deficiency anemia in tertiary hospital settings: room for improvement? Intern Med J, 2012; 42: 658–664. [PubMed] [Google Scholar]
38. Brim H, Shahnazi A, Nouraie M, Badurdeen D, Laiyemo AO, Haidary T, Afsari A, Ashktorab H. Gastrointestinal Lesions in African American Patients With Iron Deficiency Anemia. Clin Med Insights Gastroenterol, 2018; 18, 11: 1179552218778627. doi: 10.1177/1179552218778627. PMID: 29795991; PMCID: PMC5960842.
39. Garrido Durán C, Iyo Miyashiro E, Páez Cumpa C, Khorrami Minaei S, Erimeiku Barahona A, Llompart Rigo A. Rentabilidad de la cápsula endoscópica en mujeres premenopáusicas con anemia ferropénica [Diagnostic yield of video capsule endoscopy in premenopausal women with iron-deficiency anemia]. Gastroenterol Hepatol, 2015; 38(6): 373-8. Spanish. doi: 10.1016/j.gastrohep.2015.01.001. Epub 2015 Feb 18. PMID: 25700804.
40. Kepczyk T, Cremins JE, Long BD, Bachinski MB, Smith LR, McNally PR. A prospective, multidisciplinary evaluation of premenopausal women with iron-deficiency anemia. Am J Gastroenterol, 1999; 94(1): 109-15. doi: 10.1111/j.1572-0241.1999.00780. x. PMID: 9934740.
41. Moisidis-Tesch CM, Shulman LP. Iron Deficiency in Women's Health: New Insights into Diagnosis and Treatment. Adv Ther, 2022; 39(6): 2438-2451. doi: 10.1007/s12325-022-02157-7. Epub 2022 Apr 30. PMID: 35488139.
42. Windsor J.W., Kaplan G.G. Evolving Epidemiology of IBD. Curr. Gastroenterol. Rep, 2019; 21: 40. doi: 10.1007/s11894-019-0705-6.
43. Wright E.K., Kamm M.A. Impact of Drug Therapy and Surgery on Quality of Life in Crohn's Disease. Inflamm. Bowel Dis, 2015; 21: 1187–1194. doi: 10.1097/MIB.0000000000000271.
44. Shah Y, Patel D, Khan N. Iron deficiency anemia in IBD: an overlooked comorbidity. Expert Rev Gastroenterol Hepatol, 2021; 15(7): 771-781. doi: 10.1080/17474124.2021.1900730. Epub 2021 Mar 23. PMID: 33691543.
45. Mahadea D, Adamczewska E, Ratajczak AE, Rychter AM, Zawada A, Eder P, Dobrowolska A, Krela-Kaźmierczak I. Iron Deficiency Anemia in Inflammatory Bowel Diseases-A Narrative Review. Nutrients, 2021; 10, 13(11): 4008. doi: 10.3390/nu13114008. PMID: 34836263; PMCID: PMC8624004.
46. Limpias Kamiya KJL, Hosoe N, Hayashi Y, Kawaguchi T, Takabayashi K, Ogata H, Kanai T. Video capsule endoscopy in inflammatory bowel disease. DEN Open, 2021; 16, 2(1): e26. doi: 10.1002/deo2.26. PMID: 35310695; PMCID: PMC8828198.
47. Gomollón F, Dignass A, Annese V, et al. 3rd European evidence-based consensus on the diagnosis and management of Crohn's disease 2016: Part 1: Diagnosis and medical management. J Crohns Colitis, 2017; 11: 3–25.
48. Pennazio M, Spada C, Eliakim R, et al. Small-bowel capsule endoscopy and device-assisted enteroscopy for diagnosis and treatment of small-bowel

disorders: European Society of Gastrointestinal Endoscopy (ESGE) clinical guideline. Endoscopy, 2015; 47: 352–76.
49. Manes G, Fontana P, de Nucci G, Radaelli F, Hassan C, Ardizzone S. Colon cleansing for colonoscopy in patients with ulcerative colitis: Efficacy and acceptability of a 2-L PEG plus bisacodyl versus 4-L PEG. Inflamm Bowel Dis, 2015; 21: 2137–44.
50. Bruining DH, Oliva S, Fleisher MR, Fischer M, Fletcher JG. Panenteric capsule endoscopy versus ileocolonoscopy plus magnetic resonance enterography in Crohn's disease: A multicentre, prospective study. BMJ Open Gastroenterol, 2020; 7: e000365.
51. Hilmi I, Kobayashi T. Capsule endoscopy in inflammatory bowel disease: when and how. Intest Res, 2020; 18(3): 265-274. doi: 10.5217/ir.2019.09165. Epub 2020 Jul 7. PMID: 32623876; PMCID: PMC7385570.
52. Maaser C, Sturm A, Vavricka SR, et al. ECCO-ESGAR guideline for diagnostic assessment in IBD part 1: initial diagnosis, monitoring of known IBD, detection of complications. J Crohns Colitis 2019; 13: 144–164.
53. Solitano V, Zilli A, Franchellucci G, Allocca M, Fiorino G, Furfaro F, D'Amico F, Danese S, Al Awadhi S. Artificial Endoscopy and Inflammatory Bowel Disease: Welcome to the Future. J Clin Med, 2022; 24, 11(3): 569. doi: 10.3390/jcm11030569. PMID: 35160021; PMCID: PMC8836846.
54. Takenaka K., Ohtsuka K., Fujii T., Negi M., Suzuki K., Shimizu H., Oshima S., Akiyama S., Motobayashi M., Nagahori M., et al. Development and Validation of a Deep Neural Network for Accurate Evaluation of Endoscopic Images from Patients with Ulcerative Colitis. Gastroenterology, 2020; 158: 2150–2157. doi: 10.1053/j.gastro.2020.02.012.
55. Levartovsky A, Eliakim R. Video Capsule Endoscopy Plays an Important Role in the Management of Crohn's Disease. Diagnostics (Basel), 2023; 21, 13(8): 1507. doi: 10.3390/diagnostics13081507. PMID: 37189607; PMCID: PMC10137572.
56. Parigi TL, Mastrorocco E, Da Rio L, Allocca M, D'Amico F, Zilli A, Fiorino G, Danese S, Furfaro F. Evolution and New Horizons of Endoscopy in Inflammatory Bowel Diseases. J Clin Med, 2022; 7, 11(3): 872. doi: 10.3390/jcm11030872. PMID: 35160322; PMCID: PMC8837111.
57. Banerjee AK, Celentano V, Khan J, Longcroft-Wheaton G, Quine A, Bhandari P. Practical gastrointestinal investigation of iron deficiency anemia. Expert Rev Gastroenterol Hepatol, 2018; 12(3): 249-256. doi: 10.1080/17474124.2018.1404905. Epub 2017 Nov 20. Erratum in: Expert Rev Gastroenterol Hepatol, 2018; 12 (3): i. PMID: 29129158.
58. Dolatkhah R, Somi MH, Bonyadi MJ, Asvadi Kermani I, Farassati F, Dastgiri S. Colorectal cancer in Iran: molecular epidemiology and screening strategies. J Cancer Epidemiol, 2015: 2015.
59. Sung JJ, Ng SC, Chan FK, Chiu HM, Kim HS, Matsuda T. et al. An updated Asia Pacific Consensus Recommendations on colorectal cancer screening. Gut, 2015; 64(1): 121–32.
60. Alihosseini S, Aryankhesal A, Sabermahani A. Second-generation colon capsule endoscopy for detection of colorectal polyps: A meta-analysis. Med J Islam Repub Iran, 2020; 16, 34: 81. doi: 10.34171/mjiri.34.81. PMID: 33306058; PMCID: PMC7711036.
61. Kandel P, Wallace MB. Should we respect and discard low-risk diminutive colon polyps? Clin Endosc, 2019; 52: 239–46. 10.5946/ce.2018.136
62. Kaalby L, Deding U, Kobaek-Larsen M, Havshoi AV, Zimmermann-Nielsen E, Thygesen MK, Kroeijer R, Bjørsum-Meyer T, Baatrup G. Colon capsule endoscopy in colorectal cancer screening: a randomised controlled trial. BMJ Open Gastroenterol, 2020; 7(1): e000411. doi: 10.1136/bmjgast-2020-000411. PMID: 32601101; PMCID: PMC7326244.
63. Milluzzo SM, Bizzotto A, Cesaro P, Spada C. Colon capsule endoscopy and its effectiveness in the diagnosis and management of colorectal neoplastic lesions. Expert Rev Anticancer Ther, 2019; 19(1): 71-80. doi: 10.1080/14737140.2019.1538798. Epub 2018 Oct 30. PMID: 30354507.
64. Approach to incomplete colonoscopy: new techniques and technologies. Franco DL, Leighton JA, Gurudu SR. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5572961/ Gastroenterol Hepatol (N Y), 2017; 13: 476–483.
65. Current status of colon capsule endoscopy. Hosoe N, Limpias Kamiya KJ, Hayashi Y, Sujino T, Ogata H, Kanai T. Dig Endosc, 2021; 33: 529–537.
66. Koffas A, Papaefthymiou A, Laskaratos FM, Kapsoritakis A, Epstein O. Colon Capsule Endoscopy in the Diagnosis of Colon Polyps: Who Needs a Colonoscopy? Diagnostics (Basel), 2022; 29, 12(9): 2093. doi: 10.3390/diagnostics12092093. PMID: 36140494; PMCID: PMC9498104.
67. Soffer S, Klang E, Shimon O, Nachmias N, Eliakim R, Ben-Horin S, Kopylov U, Barash Y. Deep learning for wireless capsule endoscopy: a systematic review and meta-analysis. Gastrointest Endosc, 2020; 92(4): 831-839.e8. doi: 10.1016/j.gie.2020.04.039. Epub 2020 Apr 22. PMID: 32334015.
68. Zhang W, Han ZL, Cheng Y, Xu YZ, Xiao K, Li AM, Wang YD, Li Y, Liu SD. Value of the patency capsule in pre-evaluation for capsule endoscopy in cases of intestinal obstruction. J Dig Dis, 2014; 15(7): 345-51. doi: 10.1111/1751-2980.12152. PMID: 24716539.

69. Health Quality Ontario. Capsule Endoscopy in the Assessment of Obscure Gastrointestinal Bleeding: An Evidence-Based Analysis. Ont Health Technol Assess Ser, 2015; 1, 15(1): 1-55. PMID: 26357529; PMCID: PMC4561361.
70. McCarty TR, Afinogenova Y, Njei B. Use of Wireless Capsule Endoscopy for the Diagnosis and Grading of Esophageal Varices in Patients With Portal Hypertension: A Systematic Review and Meta-Analysis. J Clin Gastroenterol, 2017; 51(2): 174-182. doi: 10.1097/MCG.0000000000000589. PMID: 27548729; PMCID: PMC5218864.
71. Colli A, Gana JC, Turner D, Yap J, Adams-Webber T, Ling SC, Casazza G. Capsule endoscopy for the diagnosis of oesophageal varices in people with chronic liver disease or portal vein thrombosis. Cochrane Database Syst Rev, 2014; 1, 2014(10): CD008760. doi: 10.1002/14651858.CD008760.pub2. PMID: 25271409; PMCID: PMC7173747.
72. Kopylov U, Yung DE, Engel T, Avni T, Battat R, Ben-Horin S, Plevris JN, Eliakim R, Koulaouzidis A. Fecal calprotectin for the prediction of small-bowel Crohn's disease by capsule endoscopy: a systematic review and meta-analysis. Eur J Gastroenterol Hepatol, 2016; 28(10): 1137-44. doi: 10.1097/MEG.0000000000000692. PMID: 27415156.
73. Yung DE, Har-Noy O, Tham YS, Ben-Horin S, Eliakim R, Koulaouzidis A, Kopylov U. Capsule Endoscopy, Magnetic Resonance Enterography, and Small Bowel Ultrasound for Evaluation of Postoperative Recurrence in Crohn's Disease: Systematic Review and Meta-Analysis. Inflamm Bowel Dis, 2017; 19, 24(1): 93-100. doi: 10.1093/ibd/izx027. PMID: 29272490.
74. Kjølhede T, Ølholm AM, Kaalby L, Lindholm K, Qvist N, Baatrup G. Diagnostic accuracy of capsule endoscopy compared with colonoscopy for polyp detection: systematic review and meta-analyses. Endoscopy, 2021; 53(7): 713-721. doi: 10.1055/a-1249-3938. Epub 2020 Oct 6. PMID: 32858753.
75. Tamilarasan AG, Tran Y, Paramsothy S, Leong R. The diagnostic yield of pan-enteric capsule endoscopy in inflammatory bowel disease: A systematic review and meta-analysis. J Gastroenterol Hepatol, 2022; 37(12): 2207-2216. doi: 10.1111/jgh.16007. Epub 2022 Oct 8. PMID: 36150392; PMCID: PMC10092087.
76. Shah N, Chen C, Montano N, Cave D, Siegel R, Gentile NT, Limkakeng AT Jr, Kumar AB, Ma Y, Meltzer AC. Video capsule endoscopy for upper gastrointestinal hemorrhage in the emergency department: A systematic review and meta-analysis. Am J Emerg Med, 2020; 38(6): 1245-1252. doi: 10.1016/j.ajem.2020.03.008. Epub 2020 Mar 12. PMID: 32229221.
77. Bang CS, Lee JJ, Baik GH. Computer-Aided Diagnosis of Gastrointestinal Ulcer and Hemorrhage Using Wireless Capsule Endoscopy: Systematic Review and Diagnostic Test Accuracy Meta-analysis. J Med Internet Res., 2021 Dec 14; 23(12): e33267. doi: 10.2196/33267. Erratum in: J Med Internet Res, 2022; 11, 24(1): e36170. PMID: 34904949; PMCID: PMC8715364.
78. Han Y, Liao Z, Li Y, Zhao X, Ma S, Bao D, Qiu M, Deng J, Wang J, Qu P, Jiang C, Jia S, Yang S, Ru L, Feng J, Gao W, Huang Y, Tao L, Han Y, Yang K, Wang X, Zhang W, Wang B, Li Y, Yang Y, Li J, Sheng J, Ma Y, Cui M, Ma S, Wang X, Li Z, Stone GW. Magnetically Controlled Capsule Endoscopy for Assessment of Antiplatelet Therapy-Induced Gastrointestinal Injury. J Am Coll Cardiol, 2022; 18, 79(2): 116-128. doi: 10.1016/j.jacc.2021.10.028. Epub 2021 Nov 6. PMID: 34752902.
79. Milano A, Balatsinou C, Filippone A, Caldarella MP, Laterza F, Lapenna D, Pierdomenico SD, Pace F, Cuccurullo F, Neri M. A prospective evaluation of iron deficiency anemia in the GI endoscopy setting: role of standard endoscopy, videocapsule endoscopy, and CT-enteroclysis. Gastrointest Endosc, 2011; 73(5): 1002-8. doi: 10.1016/j.gie.2011.01.006. Epub 2011 Mar 11. PMID: 21396638.
80. Luján-Sanchis M, Pérez-Cuadrado-Robles E, García-Lledó J, Juanmartiñena Fernández JF, Elli L, Jiménez-García VA, Egea-Valenzuela J, Valle-Muñoz J, Carretero-Ribón C, et al. Role of capsule endoscopy in suspected celiac disease: A European multi-centre study. World J Gastroenterol, 2017; 28, 23(4): 703-711. doi: 10.3748/wjg.v23.i4.703. PMID: 28216978; PMCID: PMC5292345.
81. Freitas M, Macedo Silva V, Xavier S, Carvalho PB, Rosa B, Moreira MJ, Cotter J. Prolonged Gastric Transit Time in Small-Bowel Capsule Endoscopy: Which Patients Are at Risk and What Are the Implications? Turk J Gastroenterol, 2023; 34(3): 227-233. doi: 10.5152/tjg.2023.22191. PMID: 36620926; PMCID: PMC10152174.
82. Baltes P, Dray X, Riccioni ME, Pérez-Cuadrado-Robles E, Fedorov E, Wiedbrauck F, Chetcuti Zammit S, Cadoni S, Bruno M, Rondonotti E, Johansson GW, Mussetto A, Beaumont H, Perrod G, McNamara D, Plevris J, Spada C, Pinho R, Rosa B, Hervas N, Leenhardt R, Marmo C, Esteban-Delgado P, Ivanova E, Keuchel M; of the International Capsule Endoscopy Research (I-CARE) Meckel study group. Small-bowel capsule endoscopy in patients with Meckel's diverticulum: clinical features, diagnostic workup, and findings. A European multicenter I-CARE study. Gastrointest Endosc, 2023; 97(5): 917-926.e3. doi: 10.1016/j.gie.2022.12.014. Epub 2022 Dec 23. PMID: 36572128.
83. Ching HL, Hale MF, Kurien M, Campbell JA, Chetcuti Zammit S, Healy A, Thurston V, Hebden JM, Sidhu R, McAlindon ME. Diagnostic yield of magnetically assisted capsule endoscopy versus gastroscopy in recurrent and refractory iron deficiency anemia. Endoscopy, 2019; 51(5):

409-418. doi: 10.1055/a-0750-5682. Epub 2018 Oct 25. PMID: 30360012.
84. Ye CA, Gao YJ, Ge ZZ, Dai J, Li XB, Xue HB, Ran ZH, Zhao YJ. PillCam colon capsule endoscopy versus conventional colonoscopy for the detection of severity and extent of ulcerative colitis. J Dig Dis, 2013; 14(3): 117-24. doi: 10.1111/1751-2980.12005. PMID: 23134295.
85. Tjandra D, Kheslat HH, Amico F, Macrae F. Colon Capsule Endoscopy: Looking Beyond the Colon in Crohn's Disease. Inflamm Bowel Dis, 2017; 23(9): E43-E44. doi: 10.1097/MIB.0000000000001224. PMID: 28816760.
86. Juan S. Lasa, Alejandro Dutack, Ignacio Zubiaurre. DOES DIET EXERT AN INFLUENCE ON CAPSULE ENDOSCOPY INTESTINAL TRANSIT TIME?, 2018; 87(6). doi: 10.1016/j.gie.2018.04.1663
87. Geropoulos G, Aquilina J, Kakos C, Anestiadou E, Giannis D. Magnetically Controlled Capsule Endoscopy Versus Conventional Gastroscopy: A Systematic Review and Meta-Analysis. J Clin Gastroenterol, 2021; 1, 55(7): 577-585. doi: 10.1097/MCG.0000000000001540. PMID: 33883514.
88. Wang YC, Pan J, Liu YW, Sun FY, Qian YY, Jiang X, Zou WB, Xia J, Jiang B, Ru N, Zhu JH, Linghu EQ, Li ZS, Liao Z. Adverse events of video capsule endoscopy over the past two decades: a systematic review and proportion meta-analysis. BMC Gastroenterol, 2020; 2, 20(1): 364. doi: 10.1186/s12876-020-01491-w. PMID: 33138792; PMCID: PMC7607645.
89. Zeng X, Ye L, Liu J, Yuan X, Jiang S, Huang M, Huang X, Tang C, Hu B. Value of the diving method for capsule endoscopy in the examination of small-intestinal disease: a prospective randomized controlled trial. Gastrointest Endosc, 2021; 94(4): 795-802.e1. doi: 10.1016/j.gie.2021.04.018. Epub 2021 Apr 28. PMID: 33932461.
90. Marya NB, Jawaid S, Foley A, Han S, Patel K, Maranda L, Kaufman D, Bhattacharya K, Marshall C, Tennyson J, Cave DR. A randomized controlled trial comparing the efficacy of early video capsule endoscopy with the standard of care in the approach to non hematemesis GI bleeding (with videos). Gastrointest Endosc, 2019; 89(1): 33-43.e4. doi: 10.1016/j.gie.2018.06.016. Epub 2018 Jun 20. PMID: 29935143; PMCID: PMC6501558.
91. Jung ES, Lee SP, Kae SH, Kim JH, Kim HS, Jang HJ. Diagnostic Accuracy of Fecal Calprotectin for the Detection of Small Bowel Crohn's Disease through Capsule Endoscopy: An Updated Meta-Analysis and Systematic Review. Gut Liver, 2021; 15, 15(5): 732-741. doi: 10.5009/gnl20249. PMID: 33361549; PMCID: PMC8444097.
92. Xavier S, Rosa B, Monteiro S, Arieira C, Magalhães R, Cúrdia Gonçalves T, Boal Carvalho P, Magalhães J, Moreira MJ, Cotter J. Bowel preparation for small bowel capsule endoscopy - The later, the better! Dig Liver Dis, 2019; 51(10): 1388-1391. doi: 10.1016/j.dld.2019.04.014. Epub 2019 May 20. PMID: 31122824.
93. Noorbakhsh-Sabet N, Zand R, Zhang Y, Abedi V. Artificial Intelligence Transforms the Future of Health Care. Am J Med, 2019; 132: 795–801.
94. Calderaro J, Kather JN. Artificial intelligence-based pathology for gastrointestinal and hepatobiliary cancers. Gut, 2021; 70: 1183–1193. [PubMed] [Google Scholar]
95. Le Berre C, Sandborn WJ, Aridhi S, Devignes MD, Fournier L, Smaïl-Tabbone M, Danese S, Peyrin-Biroulet L. Application of Artificial Intelligence to Gastroenterology and Hepatology. Gastroenterology, 2020; 158: 76–94.e2
96. Qin K, Li J, Fang Y, Xu Y, Wu J, Zhang H, Li H, Liu S, Li Q. Convolution neural network for the diagnosis of wireless capsule endoscopy: a systematic review and meta-analysis. Surg Endosc, 2022; 36(1): 16-31. doi: 10.1007/s00464-021-08689-3. Epub 2021 Aug 23. PMID: 34426876; PMCID: PMC8741689.
97. Branchi F, Ferretti F, Orlando S, Tontini GE, Penagini R, Vecchi M, Elli L. Small-bowel capsule endoscopy in patients with celiac disease, axial versus lateral/panoramic view: Results from a prospective randomized trial. Dig Endosc, 2020; 32(5): 778-784. doi: 10.1111/den.13575. Epub 2019 Nov 26. PMID: 31680344.
98. Mi J, Han X, Wang R, Ma R, Zhao D. Diagnostic Accuracy of Wireless Capsule Endoscopy in Polyp Recognition Using Deep Learning: A Meta-Analysis. Int J Clin Pract, 2022; 19, 2022: 9338139. doi: 10.1155/2022/9338139. PMID: 35685533; PMCID: PMC9159236.
99. Perez-Cuadrado-Robles E, Lujan-Sanchis M, Elli L, Juanmartinena-Fernandez JF, Garcıa-Lledo J, Ruano-Dıaz L, Egea-Valenzuela J, Jimenez-Garcıa VA, Arguelles-Arias F, Juan-Acosta MS, Carretero-Ribon C, Alonso-Lazaro N, Rosa B, Sanchez-Ceballos F, Lopez-Higueras A, Fernandez-Urien-Sainz I, Branchi F, Valle-Muñoz J, Borque-Barrera P, Gonzalez-Vazquez S, Pons-Beltran V, Xavier S, Gonzalez-Suarez B, Herrerıas-Gutierrez JM, Perez-Cuadrado-Martınez E, Sempere-Garcıa-Arguelles J; Enteroscopy and Capsule Endoscopy Spanish Society Group of the Spanish Society of Digestive Endoscopy (SEED). Role of capsule endoscopy in alarm features and non-responsive celiac disease: A European multicenter study. Dig Endosc, 2018; 30(4): 461-466. doi: 10.1111/den.13002. Epub 2018 Jan 22. PMID: 29253321.
100. Wu X, Chen H, Gan T, et al. Automatic hookworm detection in wireless capsule endoscopy images. IEEE Trans Med Imaging, 2016; 35: 1741–1752.
101. Mascarenhas M, Afonso J, Andrade P, Cardoso H, Macedo G. Artificial intelligence and capsule endoscopy: unraveling the future. Ann Gastroenterol, 2021; 34(3): 300-309. doi:

10.20524/aog.2021.0606. Epub 2021 Feb 26. PMID: 33948053; PMCID: PMC8079882.

102. Chetcuti Zammit S, Sidhu R. Capsule endoscopy - Recent developments and future directions. Expert Rev Gastroenterol Hepatol, 2021; 15(2): 127-137. doi: 10.1080/17474124.2021.1840351. Epub 2020 Nov 3. PMID: 33111600.
103. Tziortziotis I, Laskaratos FM, Coda S. Role of Artificial Intelligence in Video Capsule Endoscopy. Diagnostics (Basel), 2021; 30, 11(7): 1192. doi: 10.3390/diagnostics11071192. PMID: 34209029; PMCID: PMC8303156.
104. Ching HL, Hale MF, McAlindon ME. The current and future role of magnetically assisted gastric capsule endoscopy in the upper gastrointestinal tract. Therap Adv Gastroenterol, 2016; 9(3): 313-21. doi: 10.1177/1756283X16633052. Epub 2016 Feb 21. PMID: 27134661; PMCID: PMC4830104.
105. Keller J., Fibbe C., Volke F., Gerber J., Mosse A., Reimann-Zawadzki M., et al. Inspection of the human stomach using remote-controlled capsule endoscopy: a feasibility study in healthy volunteers (with videos). Gastrointest Endosc, 2011; 73: 22–28.
106. Zou W., Hou X., Xin L., Liu J., Bo L., Yu G., et al. Magnetic-controlled capsule endoscopy vs. gastroscopy for gastric diseases: a two-center self-controlled comparative trial. Endoscopy, 2015; 47: 525–528.
107. Odeyinka O, Alhashimi R, Thoota S, Ashok T, Palyam V, Azam AT, Sange I. The Role of Capsule Endoscopy in Crohn's Disease: A Review. Cureus, 2022; 25, 14(7): e27242. doi: 10.7759/cureus.27242. PMID: 36039259; PMCID: PMC9401636.