

Endoscopy International Open

Retention of Endoscopic Capsules in Diverticula: A Literature Review of a Capsule Endoscopy Rarity.

Camilla Thorndal, Ola Selnes, Ian Io Lei, Sebastian Schostek, Anastasios Koulaouzidis.

Affiliations below.

DOI: 10.1055/a-2320-7104

Please cite this article as: Thorndal C, Selnes O, Lei I et al. Retention of Endoscopic Capsules in Diverticula: A Literature Review of a Capsule Endoscopy Rarity. Endoscopy International Open 2024. doi: 10.1055/a-2320-7104

Conflict of Interest: A.K.: Co-founder and shareholder of A.J.M. Medicaps; co-director and shareholder of iCERV Ltd.; consultancy fees (Jinshan Ltd.); travel support (Jinshan, Aquilant, and Dr Falk Pharma); research support (grant) from ESGE/Given Imaging Ltd. And (material) IntroMedic/SynMed; honoraria (Dr Falk Pharma UK, Ferring, Jinshan, Medtronic). Member of Advisory board meetings (Dr Falk Pharma UK, Tillots, ANKON).

SS: Affiliation with Ovesco.

The remaining authors have no conflict of interest to declare.

Abstract:

Aims: This review aims to provide an updated and comprehensive review of capsule retention within diverticula, shedding light on the characteristics and management of this rare event in capsule endoscopy.

Methods: A systematic literature search was conducted across multiple databases. All observational studies that reported capsule retention in a diverticulum among complication and outcomes, as well as case reports and series, were included. Manual cross-checking of references was also performed. Three extractors performed abstract and full-text reviews, as well as data-extraction.

Results: We found 167 references from Pubmed, Embase and Web Of Science, 65 duplicates were removed and further 71 references were excluded. Crosschecking of references found additional two articles. In total, 32 articles were included, resulting in a total of 34 cases of retained capsules in diverticula. The median age was 69 and the majority were male (76,5%). The most common retention occurred in Meckel's diverticulum (32,4%) followed by Zenker's diverticulum (20,6%). Investigation of capsule retention was done with X-ray (50%) and CT scan (44,1%). 17 cases (50%) were asymptomatic. Resolution of the retention happened with endoscopy (35,3%) and surgical management (32,4%), as well as self-resolution (20,6%).

Conclusion: Due to the small number of cases, diverticula are not a risk factor for incomplete capsule endoscopy examination. It affects mainly elderly, male, asymptomatic patients, and are typically diagnosed using X-ray and CT scans. The most common type is Meckel's diverticulum, and endoscopy was the primary management. Capsule endoscopy retentions are extremely rare, with only 34 cases reported since its introduction.

Corresponding Author:

Camilla Thorndal, Odense Universitetshospital Kirurgisk Afdeling A, Surgical Research Unit, Baagøes Alle 15, indgang 41, 5000 Odense, Denmark, camilla.thorndal.nielsen@rsyd.dk

Affiliations:

Camilla Thorndal, Odense Universitetshospital Kirurgisk Afdeling A, Surgical Research Unit, Odense, Denmark

Ola Selnes, Odense Universitetshospital Kirurgisk Afdeling A, Surgical Research Unit, Odense, Denmark

Ian Io Lei, University Hospital Coventry, Coventry, United Kingdom of Great Britain and Northern Ireland

[...]



Appendix

A1: Search strategy

Bloc 1: Investigation		Bloc 2: Comparator		Bloc 3: Outcome
Capsule*	A N D	Diverticula*	A N D	Retention*
OR		OR		OR
Videoendoscop*		Diverticulum*		Lodged*
OR		OR		OR
Video-Endoscopy*		Meckel*		Entrap*
OR		OR		
Video capsule*		Zenker*		
OR		OR		
Wireless Camera*		Diverticulum**		
OR				
Wireless Capsule*				
OR				
WCE*				
OR				
SBCE*				
OR				
CCE*				
OR				
Capsule Endoscopy**				

*Text words: to identify all terms regardless of term form.

**MeSH terms/ WoS terms

A2: PubMed Search

((((((((((capsule*) OR (videoendoscop*)) OR (Video-Endoscopy*)) OR (Video capsule*)) OR (Wireless Camera*)) OR (WCE*)) OR (SBCE*)) OR (CCE*)) OR (capsule endoscopy[MeSH])) AND (((((Diverticula*) OR (Diverticulum*)) OR (Meckel*)) OR (Zenker*)) OR (Diverticulum[MeSH]))) AND (((Retention*) OR (Lodged*)) OR (Entrap*))

35 hits in total.

A3: Web of Science Search

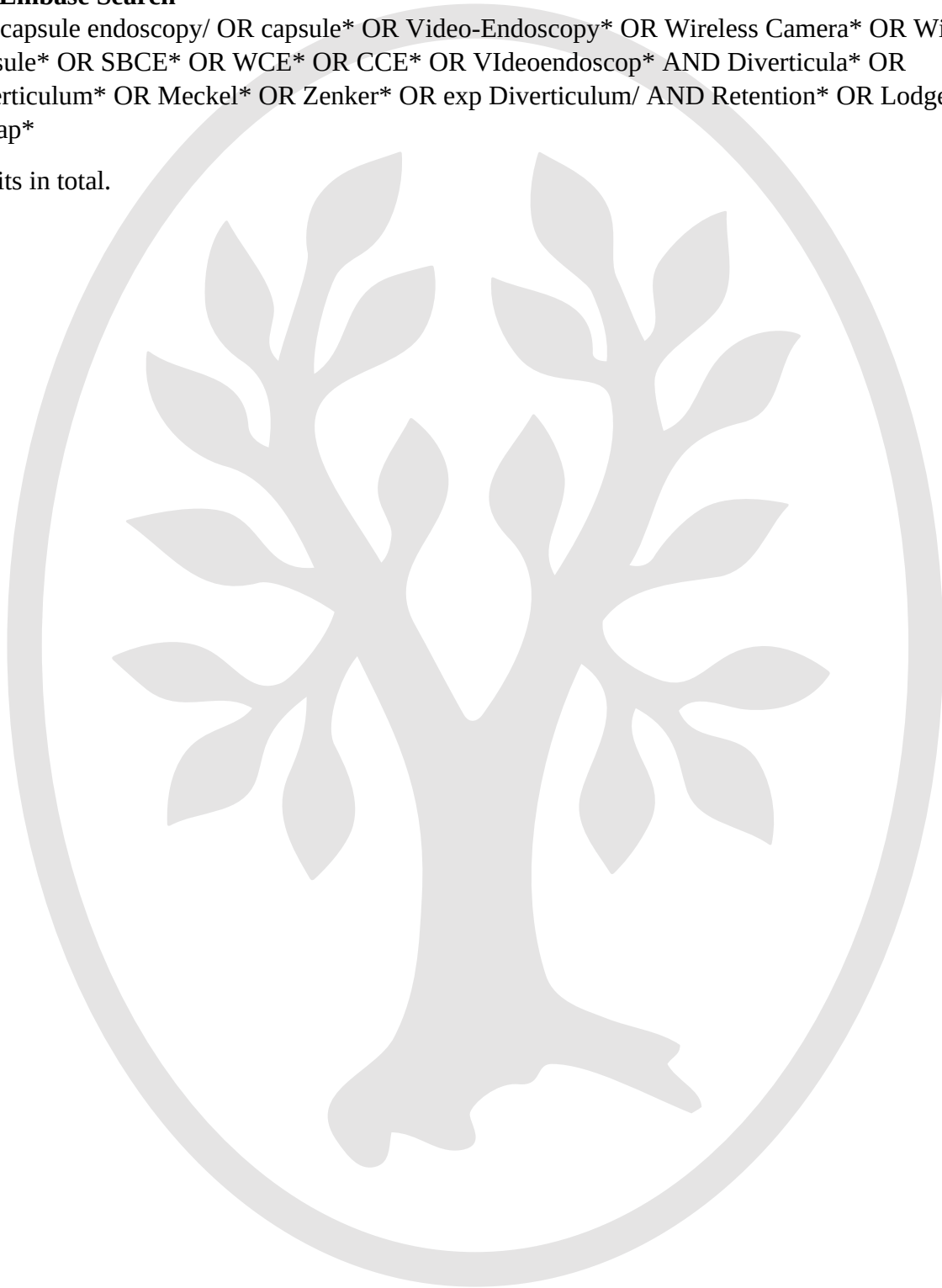
((((((((((ALL=(Capsule*)) OR ALL=(Videoendoscop*)) OR ALL=(Video-Endoscopy*)) OR ALL=(Wireless Camera*)) OR ALL=(Wireless Capsule*)) OR ALL=(WCE*)) OR ALL=(SBCE*)) OR ALL=(CCE*)) OR WC=Capsule Endoscopy) AND ALL=(Retention*) OR ALL=(Lodged*) OR ALL=(Entrap*)) AND (((((ALL=(Diverticula*)) OR ALL=(Diverticulum*)) OR ALL=(Meckel*)) OR ALL=(Zenker*)) OR WC=(Diverticulum))

34 hits in total.

A4: Embase Search

Exp capsule endoscopy/ OR capsule* OR Video-Endoscopy* OR Wireless Camera* OR Wireless Capsule* OR SBCE* OR WCE* OR CCE* OR Videoendoscop* AND Diverticula* OR Diverticulum* OR Meckel* OR Zenker* OR exp Diverticulum/ AND Retention* OR Lodged* OR Entrap*

98 hits in total.



Introduction

Capsule endoscopy (CE) is widely accepted as a non-invasive way to evaluate the gastrointestinal (GI) tract and is the leading modality for the investigation of occult GI bleeding (OGIB), and other small bowel (SB) diseases [1]. The safety profile of CE has been thoroughly examined over the past years, and many have investigated the adverse events (AE), with the most common AE being capsule retention [2, 3]. Retention of the capsule is defined as the presence of the capsule in the GI tract for at least 2 weeks after ingestion, or indefinitely retained unless endoscopic or surgical intervention has been done [4]. Capsule retention within SB or colonic diverticula was a complication postulated at the introduction of CE but was shown to be very infrequent and/or without clinically relevant consequences [5, 6]. A proportion of capsules is retained, usually due to Crohn's disease or non-steroidal use strictures [1, 7, 8], but retention has also been linked to tumors in the SB and previous GI surgery [2, 3]. SB diverticula can occur anywhere in the SB but are most often found in the duodenum. A retrospective review of 208 patients with symptomatic SB diverticulosis reported diverticula in the duodenum in 79% of the patients, in the jejunum or ileum in 18% of the patients, and in all three segments in 3% of the patients [9]. Jejunoileal diverticula are rare and reported to affect 0.5 to 2.3% of individuals in radiographic series [10]. Colonic diverticula disease prevalence in western patients was found to be 15-35% [11].

The aim of this review is to compile the available data on the retention of capsule endoscopes in diverticula to provide an overview and characteristics of this adverse event.

Methods

A systematic literature search was conducted in the PubMed, Embase, and Web Of Science databases. Three groups of search terms were defined: *investigation*, *comparator*, and *outcome*. These three groups each included relevant terms using the Boolean expression "OR" within the groups and the Boolean expression "AND" for combining the groups. The '*investigation*' group was used to identify papers on capsule endoscopy. The '*comparator*' groups were used to limit results to references which included diverticula. Finally, the '*outcome*' groups were to restrict results to papers reporting on the retention of the capsules. The search strategy is provided in **Appendix A**. There was applied no limit to the publication year. Cohort studies and case reports/series were included if describing individuals with capsule retention in any type of diverticula. No exclusions were based on language.

The final literature search was conducted on 4th May 2023. Specific search strings are provided in **Appendix A**. Two authors (C.T. and O.S.) screened titles and abstracts independently. Papers meeting the inclusion criteria were included for full-text screening, which was also done in detail by two independent authors (C.T. and O.S.) In case of discrepancies, the authors would re-read and discuss the article. In the case of an unknown language, help was sought from other authors. To ensure the search was adequate, crosschecking was done to screen the reference lists of the included papers for further possible relevant articles. From each included reference, two authors independently extracted data needed for analysis. The outcome data extracted was study type, sex and age of the patients, reported reason for undergoing CE, investigation modalities used before CE, capsule modality, type of diverticulum, retention investigation process, how long the retention

lasted, whether or not the patient had symptoms and the course of treatment of the retention. Where appropriate, data extraction and statistical analyses were done using Microsoft Excel 2010 (Microsoft Corp., Redmond, Washington, USA). Numerical results are reported as percentages.

Results

The initial literature search resulted in 167 references from PubMed, Embase and Web of Science, 65 duplicates were removed, and 71 references did not meet the inclusion criteria of retention in a diverticula and were excluded, with reasons categorized by *investigation* (10/71), *comparator* (46/71), and *outcome* (15/71) as defined in the method paragraph. A thorough crosschecking of references found additional two articles.

In total, 32 articles were included, resulting in a total of 34 cases of retained capsules in diverticula [1, 12-42]. An overview of the specific search results is provided in **Figure 1** and an overview of the included articles is provided in **Table 1**.

Figure 1: Flowchart of search result

Table 1: Overview of cases.

Patient details

Of the 34 cases, eight (23,5%) were female and the mean age of individuals ranged from 12 to 87 years, with a median age of 69 years. Reasons for undergoing CE varied; 10 (29,4%) patients experienced OGIB, seven (20,6%) had hematochezia and another seven (20,6%) described melena. Only one (2,9%) reported loose stools [30]. 17 (50%) cases reported anemia as the reason for undergoing CE including 10 (58,8%) with iron deficiency anemia, three (17,6%) with microcytic anemia, three (17,6%) with unspecified anemia and the last one with an acute drop in hemoglobin. This patient also experienced acute melena, hallucinations, and cough for two days prior [28]. Four (11,8%) patients had pain as the reason for undergoing CE. Three were described as abdominal pain and the fourth was specifically intermittent periumbilical pain. One patient experienced syncope [21], and another patient had a positive fecal occult blood test [36]. The investigation modalities used before the patients underwent CE was primarily gastroscopy (27 cases, 79,4%) and colonoscopy (26 cases, 76,5%). Other modalities were CT scan (4, 11,8%), push enteroscopy (3, 8,8%), CT enterography (3, 8,8%), CT angiography (2, 5,9%), technetium-99m pertechnetate scan (2, 5,9%), small bowel radiology (2, 5,9%), SB follow-through (1, 2,9%), arteriography (1, 2,9%), X-ray (1, 2,9%), and gastric lavage using a nasogastric tube (1, 2,9%). Five (14,7%) cases did not report any prior investigations.

Capsule specifications

In 16 (47%) cases, the company and model of CE were not specified. 13 (38,2%) patients were examined using capsules from Given Imaging Ltd (now Medtronic, Minneapolis, Minnesota, USA): six used M2A capsules, one used PillCam SB, three used PillCam SB2, one used PillCam SB3 and the remaining two were nonspecific. Two cases used MiroCam, IntroMedic. One used Olympus and one used CapsoRetire (possibly CapsoCam, CapsoVision). 31 (91,2%) cases reported capsule modality and all of these were for small bowel investigation.

Presentation of diverticula retention

Within the 34 cases in total, the most common retention was within Meckel's diverticulum (32,4%), in 11 cases. Seven patients (20,6%) experienced capsule retention in Zenker's diverticula. Four (11,8%) were in the jejunum and four (11,8%) capsule retentions happened in the colon. Three (8,8%) retentions happened in the duodenum and two (5,8%) retentions were in esophageal diverticula; one was described as epiphrenic [26]. Two (5,8%) had a non-specific small bowel location in proximal and distal, respectively, and the patient with capsule retention in distal SB diverticula had two separate diverticula [16]. One (2,9%) capsule retention was in a gastric diverticulum. 17 (50%) cases investigated capsule retention with X-ray and 15 (44,1%) used computer tomography (CT) scan. In 14 (41,2%) cases, the capsule videos were reviewed as part of the standard investigation process after the video upload, and in two (5,8%) cases, a real-time viewer was used. In five (14,7%) patients, the capsule was not excreted, which led to suspected capsule retention. In three (8,8%) patients, the first clue on retention was either discomfort in the cervical region [22], pain in the lower abdomen [17] or a sensation in the esophagus [14]. In total, nine (26,5%) patients had symptoms of retention, 17 (50%) cases were asymptomatic and eight (23,5%) did not report whether symptomatic or not. One patient experienced dysphagia two years after ingestion of the capsule, which was lodged in a Zenker's diverticulum [39]. One patient brought in a delayed expelled capsule 34 days after ingestion, and the capsule video showed capsule retention in a Zenker's diverticulum [29]. Retention rates exhibit significant variation over time, ranging from the longest case, which lasted 7,5 years within a Meckel's diverticulum of a young man [31], to the shortest case lasting only one hour in a Zenker's diverticulum [14].

Management of capsule retention in diverticula

The retention was self-resolved in seven (20,6%) patients. Twelve (35,3%) patients had an endoscopic treatment, out of which six underwent gastroscopy, two had a double-balloon enteroscopy (DBE) and the remainder was not specified. A polypectomy snare to retrieve the capsule was used in 2 occasions, Roth Net in five, and in one occasion an unspecified retrieval basket. Surgical management was used in 11 (32,4%) cases, in eight of them resection of the diverticular segment was performed, two did not specify resection, and in one case the surgical procedure was non-specified. Five cases underwent a laparoscopic approach, where one was converted to a laparotomy [33]. Even though the surgical approach was pursued due to the actual retention in all 11 cases, only 3 instances offered a clear explanation for choosing surgical management was provided in three cases: in one case, an attempted endoscopic retrieval via a colonoscopy failed [12]. In another case, both upper and lower endoscopies were attempted but failed [33], and the third case, the retrieval attempt of the capsule endoscope via flexible sigmoidoscopy failed due to the epithelialization of the mucosa around the capsule [37]. There was no clear pattern in management of the nine symptomatic cases, however four cases received a surgical approach with resection [17, 33, 37, 41] four cases had an endoscopy [14, 22, 30, 39] and the last case was self-resolved [29].

Discussion

This comprehensive literature review reveals the rarity of capsule retentions within diverticula. It predominantly affects elderly male patients, with Meckel's diverticulum being the most common

cause. Diagnostics were primarily conducted using X-ray and CT scans; in most cases, patients were asymptomatic. Resolution was primarily achieved through endoscopy, but occasionally laparoscopic approach became necessary, and some cases resolved spontaneously.

Careful and meticulous patient selection for capsule endoscopy is, however, essential. The rate of capsule retention is low in most studies due to the careful selection of study populations, excluding patients who are at risk of SB obstruction or intestinal stricture [8]. However, the patients included in this review had undiagnosed diverticula, and for apparent reasons, they could not be excluded. This reflects the challenges encountered in real-world situations.

Given the low percentage of retention cases, identifying high-risk patients is challenging. Perhaps, it's more important to direct our focus toward optimizing capsule retention management techniques and outcomes when capsule retention in diverticula arises. A case report propose to perform ingestion under visual guidance via gastroscopy in patients with known gastric diverticulum, adding new dimensions to enhancing procedural precision [38]. In another case, the capsule was secured to a conventional endoscope using a snare and released directly into the stomach of a patient with a Zenker's diverticulum, hereby bypassing the diverticulum [43].

Within the well-established yet limited landscape of adverse events in capsule endoscopy, this review sheds light on the potential complication associated with previously documented retention rates in the range of 0.73% to 2% [2, 3, 44]. Most capsule retentions are attributed to strictures secondary to conditions such as inflammatory bowel disease (IBD) or nonsteroidal anti-inflammatory drugs (NSAIDs) [44], and there is scarcely documented retention within diverticula, which is supported by our review with only 5 studies (1 RCT and 4 retrospective studies) mentioning this particular occurrence. However, there is an infrequent occurrence of capsule retention within Meckel's diverticulum and a likelihood of spontaneous passage, particularly in asymptomatic cases [40]. When it comes to management of capsule retention, the prospect of a capsule eventually passing after several months further accentuates the need for balanced consideration between symptomatic and asymptomatic scenarios. Notably, capsule retention stands out as a significant concern due to its potential complication of gastrointestinal obstruction. In a review, it was evident that only a minority of patients experienced obstructive symptoms, leading to the conclusion that capsule retention rarely results in serious obstructive symptoms [44]. However, in their analysis, 57% of retentions underwent surgical management, although not all were due to obstructive symptoms. They speculate whether the intention for the surgical management was due to the surgical expertise available at the study center and the lack of availability of endoscopic options, or the intention to prevent future adverse events from retained capsules especially when repeated capsule procedures were anticipated [44]. The optimal management of capsule retention remains a subject of debate, and surgical intervention is not the recommended primary standard of care [1, 8, 38]. According to the European Society of Gastrointestinal Endoscopy (ESGE) guidelines on small bowel capsule endoscopy and device-assisted endoscopy, they recommend starting with conservative treatment in cases of capsule retention. An endoscopic retrieval attempt should be considered when medical therapy proves ineffective [45]. Surgical management is only indicated in patients with obstructive symptoms, an occurrence that is not typically expected in cases of capsule retention within the diverticula.

As presented in our review, surgery was chosen as the primary approach to address capsule retention. However, this approach may have been overly aggressive, and primarily driven by the fear of bowel obstruction from the retained capsule, as it was apparent that a limited number of

surgeons attempted alternative modalities first. Furthermore, it is speculated whether surgery in patients with retained capsules and known Crohn's disease or NSAID strictures could have been avoidable with optimal medical treatment [46].

A prominent concern emerges from the fact that 12 out of 25 cases fail to align with the established criteria mandating a 14-day retention period within the gastrointestinal (GI) tract. This discrepancy prompts an exploration of whether the same yardstick should be applied to capsule retention within diverticula. If not, this raises the question of how to navigate and address this issue. The inadvertent presence of a capsule within a diverticulum, although undesirable, also raises the question of whether a distinction should be drawn between a capsule incidentally entering a diverticulum during its journey through the GI tract, irrespective of a specific time threshold, and a genuine retention that extends for a full 14-day period. Addressing this differentiation is essential for a more nuanced understanding of capsule endoscopy outcomes and bears implications for clinical practice.

This review aims to present an updated and thorough analysis of available evidence regarding capsule retention in diverticula. Among the 34 cases included in this review, 29 were derived from case reports. It is important to note that not all instances of capsule retention in diverticula are reported or published. One of the limitations of our search lies in the possibility of missing cases due to language and accessibility limitations, potentially introducing bias in the selection process and leading to an underestimation of the true incidence. Furthermore, only 5 studies reported retention as a complication or outcome, suggesting a potential underreporting and missing data on this occurrence. Nevertheless, despite the retrospective nature of case reports without statistical calculations, the included articles have been deemed appropriate for the purpose of this review, indicating their adequacy in terms of quality. While we acknowledge the possibility of undetected or unreported cases, this review represents the current and comprehensive compilation of relevant information, facilitating a more accurate estimation of the rate of capsule retention in diverticula.

Conclusion

In conclusion, it appears that, due to the small number of cases, diverticula are not a risk factor for incomplete capsule endoscopy examination. It affects mainly old male patients who are mostly asymptomatic. X-ray and CT scans emerged as the predominant diagnostic modalities. The most common cause was Meckel's diverticulum and endoscopy was the primary management. Retentions are very rare and only anecdotal, as only 34 cases have been reported since the introduction of capsule endoscopy. When considering capsule retention in diverticula, there have been no reports of severe clinical consequences or symptoms, and the probability of such occurrences is low.

Figure legends and tables

Figure 1: Flowchart of search results.

Figure 1: Flowchart of search result



A6: Table 1: overview of cases.

Table 1: Overview of cases.

Case	Study type	Sex	Age	Investigation modalities used before CE	Reported reason for CE	Capsule brand	Capsule modality	Type of diverticulum	Retention investigation process	How long lasted the retention?	Symptoms?	Management of retention
Chen et al. [12]	CR	M	55	Gas, Colo, PE, CT scan, AG, SB radio, Tc99m	OGIB	NR	SB	Meckel's	No excreted capsule, Abdominal X-ray, explorative laparotomy	>4 months	No	Surgical (Laparotomy, resection)
Chen et al.[13]	CR	F	73	Gas, Colo, SB F-T	Melena, Anemia	GIVEN	SB	Zenker's	Viewing capsule data, Neck X-ray	8 hours	No	Endoscopic
Chen et al.[14]	CR	M	73	PE, SB radio	Melena	GIVEN	SB	Zenker's	Sensation in proximal esophagus, X-ray	1 hour	Yes	Endoscopic (polypectomy snare)
Chen et al.[15]	CR	M	79	Gas, Colo	Anemia	NR	SB	Zenker's	Precautionary X-ray	NR	No	Endoscopic (Gastroscopy, polypectomy snare)
Chen et al.[16]	CR	F	60	Gas, Colo	IDA	M2A GIVEN	SB	Distal SB (2 separate)	No excreted capsule, CT scan	>2 months	No	NR
Chen et al.[17]	CR	F	69	Gas, Colo, PE	OGIB	M2A GIVEN	SB	Meckel's	Lower quadrant abdominal pain, CT scan	>4 months	Yes	Surgical (Laparoscopy, resection)
Chen et al.[18]	Re.	NR	NR	NR	NR for specific case	M2A GIVEN	SB	Duodenal	Viewing capsule data	40 hours	No	Self-resolved
Chen et al.[19]	CR	F	74	Gas, Colo	Microcytic anemia	M2A GIVEN	SB	Duodenal	Abdominal X-ray	3 weeks	No	Endoscopic (Gastroscopy, Roth Net)
Chen et al.[20]	CR	M	82	Gas, Colo	OGIB	M2A GIVEN	SB	Proximal SB	Viewing capsule data, Abdominal X-ray	16 days	No	Self-resolved
Chen et al.[21]	CR	M	20	Gas, Colo	Hematochezia, Syncope	PillCam SB2	SB	Meckel's	Viewing capsule data, DBE	1 day	No	Endoscopic (DBE, polypectomy snare)
Chen et al.[22]	CR	M	66	Gas, Colo, X-ray	Melena, slight IDA	Olympus	SB	Zenker's	Discomfort in cervical region, real time viewer	<1 day	Yes	Endoscopic (Roth Net)
Chen et al.[23]	Re.	NR	NR	NR	NR	NR	NR	Colonic	NR	NR	NR	Endoscopic (DBE, Roth Net)
Chen et al.[24]	CR	M	71	Gas, Colo	OGIB	M2A GIVEN	SB	Zenker's	Viewing capsule data, Contrast swallow X-ray	NR	No	Endoscopic (Gastroscopy, Roth Net)
Chen et al.[25]	CR	M	58	Gas, Colo	Abdominal pain, melena, IDA	PillCam SB2	SB	Meckel's	Viewing capsule data, CT scan	NR	No	Surgical (non-specific operation)
Chen et al.[26]	CR	F	73	NR	IDA, OGIB	PillCam SB	SB	Esophageal epiphrenic	Viewing capsule data, Esophagram, second VCE	>8 hours, but not specified	No	Self-resolved
Chen et al.[27]	Re.	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chen et al.[28]	CR	M	55	Gas, Colo,	Hallucinations	NR	SB	Colonic	No excreted capsule,	5 days	No	Self-resolved

				CT EG	and cough for 2 days, acute drop in hemoglobin, melena				Abdominal X-ray			
et al.[29]	CR	M	80	Gas, Colo	IDA	MiroCam MC1000	SB	Zenker's	Viewing capsule data, patient brings in expelled capsule	34 days	Yes	Self-resolved
al.[30]	CR	M	69	CT scan, Colo	Hematochezia, loose stools	MiroCam IntroMedic	SB	Duodenal	Viewing capsule data, CT scan, X-ray	1 day	Yes	Endoscopic (Gastroscopy, Retrieval basket)
al.[31]	CR	M	32	Gas, Colo, CT AG	OGIB 7,5 year earlier led to CE, pt. lost to follow up, now melena, IDA	OMOM	NR	Meckel's	X-ray, CT scan	7,5 year	No	Surgical (non-specific operation)
n et al.[1]	CR	F	75	Gas	OGIB	NR	SB	Esophagus	NR	NR	NR	Endoscopic (Gastroscopy)
Compean et al.	CR	M	18	Gas, Colo, CT EG	Hematochezia, anemia	NR	SB	Meckel's	Viewing capsule data, Abdominal X-ray, CT scan	7 days	NR	Surgical (Laparoascopy)
alderrama et	CR	M	44	Gas, Colo	IDA	PillCam SB3	SB	Meckel's	Viewing capsule data, Abdominal X-ray, CT scan	NR	Yes	Surgical (Laparoscopy, laparotomy, resection)
al.[34]	CR	M	19	Gas, Colo, CT scan	Intermittent periumbilical pain	PillCam SB2	SB	Meckel's	Viewing capsule data	2 hours	No	No treatment
ski et al.[35]	RCT	NR	NR	Gas	OGIB	NR	SB	Jejunal	NR	NR	NR	NR
t al.[36]	CR	M	12	Gas, Colo, Tc99m, CT AG, CT EG	Hematochezia, abdominal pain, FOBT+	NR	SB	Meckel's	NR	NR	NR	Surgical (Laparoscopy, diverticulectomy)
za et al.[37]	CR	F	65	Gas, Colo	IDA	NR	SB	Colonic (sigmoid)	CT scan	>4 years	Yes	Surgical (Sigmoid colectomy)
al.[38]	CR	F	80	Gas, Colo	Microcytic anemia, Hematochezia	CapsoRetire	SB	Gastric	No excreted capsule, X-ray, CT scan	2 weeks	No	Endoscopic (Gastroscopy)
al.[38]	CR	M	84	Gastric lavage	Microcytic anemia, recurrent melena	NR	SB	Jejunal	No excreted capsule, X-ray, CT scan	21 days	NR	Surgical (Laparoscopy, resection)
al.[39]	CR	M	75	NR	OGIB	NR	SB	Zenker's	2 X-rays negative, dysphagia 2 years later led to CT scan	2 years	Yes	Endoscopic (Endoscopy, Roth Net)
m et al.[40]	CR	M	59	Gas, Colo	Chronic IDA, OGIB	NR	SB	Meckel's	Viewing capsule data, CT scan	<6 months	No	Self-resolved
lcazar et al.[41]	CR	M	71	Gas, Colo	Melena	NR	SB	Jejunal	Viewing capsule data, X-ray, CT scan	5 days	Yes	Surgical (Laparotomy, resection)
lcazar et al.[41]	CR	M	87	Gas, Colo	Hematochezia	NR	SB	Jejunal	Real time video, CT	19 hours	No	Self-resolved
et al.[42]	CR	M	32	Gas, Colo,	IDA,	NR	SB	Meckel's	CT scan, Abdominal X-	NR	NR	Surgical (Laparotomy, resection)

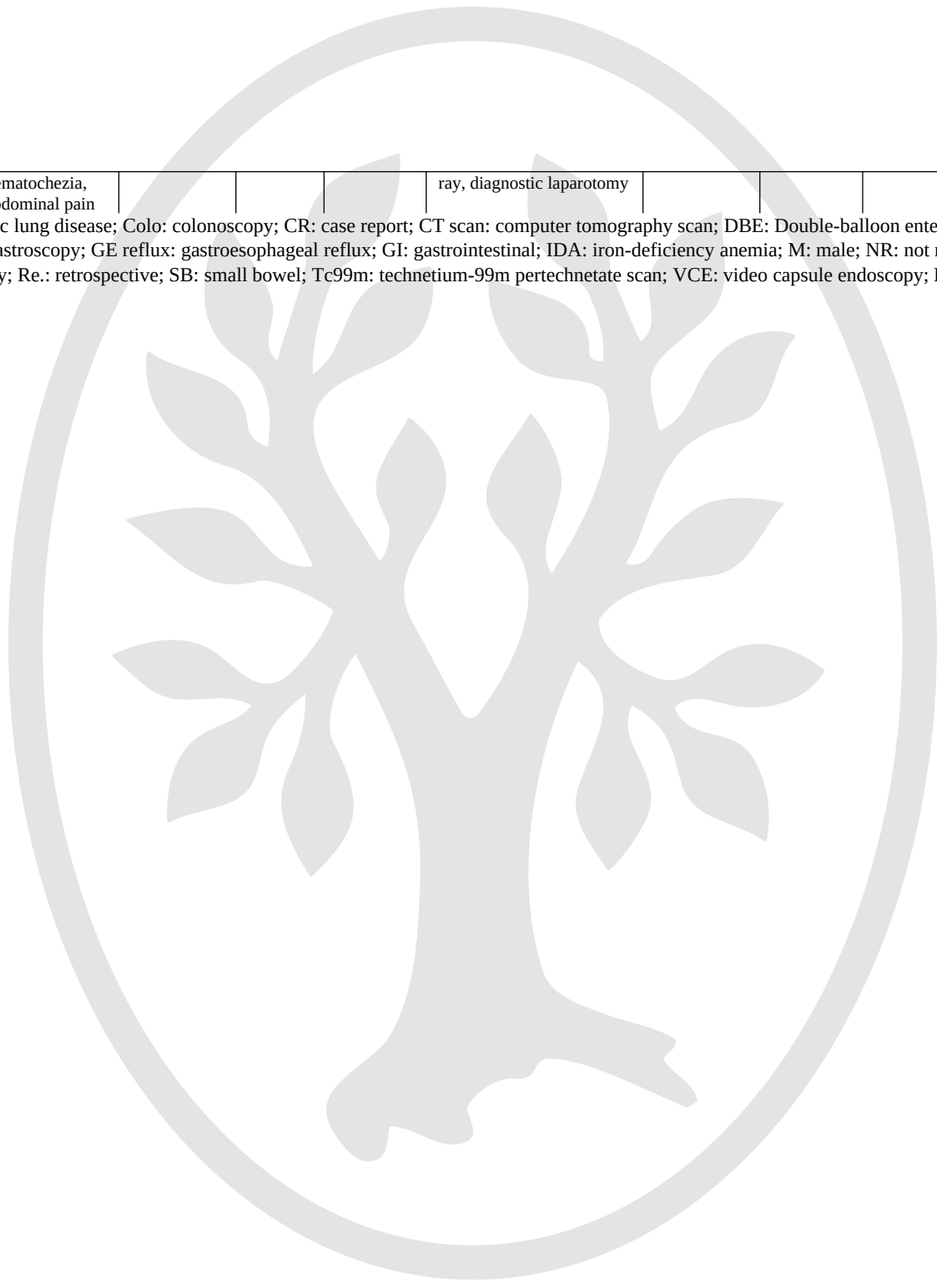
CT scan

hematochezia,
abdominal pain

ray, diagnostic laparotomy

Abbreviations: AG: angiography; CLD: chronic lung disease; Colo: colonoscopy; CR: case report; CT scan: computer tomography scan; DBE: Double-balloon enteroscopy; EG: enterograh; F: Female; FOBT+: fecal occult blood test positive; Gas: gastroscopy; GE reflux: gastroesophageal reflux; GI: gastrointestinal; IDA: iron-deficiency anemia; M: male; NR: not reported; OGIB: obscure gastrointestinal bleeding; PE: push enteroscopy; radio: radiology; Re.: retrospective; SB: small bowel; Tc99m: technetium-99m pertechnetate scan; VCE: video capsule endoscopy; F-T: follow-through.

This article is protected by copyright. All rights reserved.



Accepted Manuscript

References:

1. Nemeth A, Wurm Johansson G, Nielsen J et al. Capsule retention related to small bowel capsule endoscopy: a large European single-center 10-year clinical experience. *United European Gastroenterol J* 2017; 5: 677-686. DOI: 10.1177/2050640616675219
2. Wang YC, Pan J, Liu YW et al. Adverse events of video capsule endoscopy over the past two decades: a systematic review and proportion meta-analysis. *BMC Gastroenterol* 2020; 20: 364. DOI: 10.1186/s12876-020-01491-w
3. Cortegoso Valdivia P, Skonieczna-Żydecka K, Elosua A et al. Indications, Detection, Completion and Retention Rates of Capsule Endoscopy in Two Decades of Use: A Systematic Review and Meta-Analysis. *Diagnostics (Basel)* 2022; 12. DOI: 10.3390/diagnostics12051105
4. Hoog CM, Bark LA, Arkani J et al. Capsule retentions and incomplete capsule endoscopy examinations: an analysis of 2300 examinations. *Gastroenterol Res Pract* 2012; 2012: 518718. DOI: 10.1155/2012/518718
5. Rondonotti E, Spada C, Adler S et al. Small-bowel capsule endoscopy and device-assisted enteroscopy for diagnosis and treatment of small-bowel disorders: European Society of Gastrointestinal Endoscopy (ESGE) Technical Review. *Endoscopy* 2018; 50: 423-446. DOI: 10.1055/a-0576-0566
6. Koulaouzidis A, Rondonotti E, Karargyris A. Small-bowel capsule endoscopy: a ten-point contemporary review. *World J Gastroenterol* 2013; 19: 3726-3746. DOI: 10.3748/wjg.v19.i24.3726
7. Tashiro Y, Kawai M, Takehara K et al. Successful retrieval of a retained capsule endoscope with single incision laparoscopic surgery. *Case Rep Gastroenterol* 2014; 8: 206-210. DOI: 10.1159/000364821
8. Rondonotti E. Capsule retention: prevention, diagnosis and management. *Ann Transl Med* 2017; 5: 198. DOI: 10.21037/atm.2017.03.15
9. Akhrass R, Yaffe MB, Fischer C et al. Small-bowel diverticulosis: perceptions and reality. *J Am Coll Surg* 1997; 184: 383-388.
10. De Peuter B, Box I, Vanheste R et al. Small-bowel diverticulosis: imaging findings and review of three cases. *Gastroenterol Res Pract* 2009; 2009: 549853. DOI: 10.1155/2009/549853
11. Tănase I, Păun S, Stoica B et al. Epidemiology of diverticular disease -- systematic review of the literature. *Chirurgia (Bucur)* 2015; 110: 9-14.
12. Gortzak Y, Lantsberg L, Odes HS. Video Capsule entrapped in a Meckel's diverticulum. *J Clin Gastroenterol* 2003; 37: 270-271. DOI: 10.1097/00004836-200309000-00016
13. Ford RM, Affronti J, Cohen R et al. Zenker's diverticulum: a contraindication for wireless capsule endoscopy? *J Clin Gastroenterol* 2005; 39: 257. DOI: 10.1097/01.mcg.0000152750.02645.b1
14. Simmons DT, Baron TH. Endoscopic retrieval of a capsule endoscope from a Zenker's diverticulum. *Dis Esophagus* 2005; 18: 338-339. DOI: 10.1111/j.1442-2050.2005.00509.x
15. Knapp AB, Ladetsky L. Endoscopic retrieval of a small bowel enteroscopy capsule lodged in a Zenker's diverticulum. *Clin Gastroenterol Hepatol* 2005; 3: xxxiv. DOI: 10.1016/s1542-3565(04)00552-x
16. Gaba RC, Schlesinger PK, Wilbur AC. Endoscopic video capsules: radiologic findings of spontaneous entrapment in small intestinal diverticula. *AJR Am J Roentgenol* 2005; 185: 1048-1050. DOI: 10.2214/ajr.04.1297
17. Yu WK, Yang RD. M2A video capsule lodged in the Meckel's diverticulum. *Gastrointest Endosc* 2006; 63: 1071-1072; discussion 1072. DOI: 10.1016/j.gie.2005.11.020
18. Wei W, Ge ZZ, Gao YJ et al. An analysis of failure and safety profiles of capsule endoscopy. [Chinese]. *Zhonghua nei ke za zhi [Chinese journal of internal medicine]* 2008; 47(1): 19-22.
19. Ordubadi P, Blaha B, Schmid A et al. Capsule endoscopy with retention of the capsule in a duodenal diverticulum. *Endoscopy* 2008; 40 Suppl 2: E247-248. DOI: 10.1055/s-2008-1077563

20. Giday SA, Pickett-Blakely OE, Buscaglia JM et al. Capsule retention in a patient with small-bowel diverticulosis. *Gastrointest Endosc* 2009; 69: 384-386. DOI: 10.1016/j.gie.2008.03.1085
21. Tanaka Y, Motomura Y, Akahoshi K et al. Capsule endoscopic detection of bleeding Meckel's diverticulum, with capsule retention in the diverticulum. *Endoscopy* 2010; 42 Suppl 2: E199-200. DOI: 10.1055/s-0030-1255696
22. Horiuchi A, Nakayama Y, Kajiyama M et al. Video capsule retention in a Zenker diverticulum. *Case Rep Gastroenterol* 2011; 5: 361-365. DOI: 10.1159/000329882
23. Sonpal N, Vadada D, Bershadskiy A et al. Double-balloon enteroscopy for retrieval of retained small-bowel video capsules - A single center experience. *American Journal of Gastroenterology* 2011; 2): S97. DOI: https://dx.doi.org/10.1038/ajg.2011.336_4
24. Ziachehabi A, Maieron A, Hoheisel U et al. Capsule retention in a Zenker's diverticulum. *Endoscopy* 2011; 43 Suppl 2 UCTN: E387. DOI: 10.1055/s-0030-1256931
25. Courcoutsakis N, Pitiakoudis M, Mimidis K et al. Capsule retention in a giant Meckel's diverticulum containing multiple enteroliths. *Endoscopy* 2011; 43 Suppl 2 UCTN: E308-309. DOI: 10.1055/s-0030-1256641
26. Ekanayake P, Parikh D, Mittal M et al. A Case of Video Capsule Retention in a Rare Epiphrenic Diverticulum. *American Journal of Gastroenterology* 2012; 107: S529-S529. DOI: 10.14309/00000434-201210001-01333
27. Verma AM, Ramiah R, Legge D et al. Small bowel capsule endoscopy: A review of 232 studies undertaken at a single centre. *Gut* 2012; 2): A243-A244. DOI: <https://dx.doi.org/10.1136/gutjnl-2012-302514c.142>
28. Anderson BW, Liang JJ, Dejesus RS. Capsule endoscopy device retention and magnetic resonance imaging. *Proc (Bayl Univ Med Cent)* 2013; 26: 270-271. DOI: 10.1080/08998280.2013.11928979
29. Garcia FMA, Pozo JMP, Alcalá FM. Inadvertent and asymptomatic retention of an endoscopic capsule in a Zenker diverticulum. *Gastroenterologia Y Hepatologia* 2014; 37: 272-273. DOI: 10.1016/j.gastrohep.2013.10.007
30. Kim S, Bae SS, Chu HJ et al. Capsule Endoscopy with Retention of the Capsule in a Duodenal Diverticulum: A Case Report. *Korean J Gastroenterol* 2016; 67: 207-211. DOI: 10.4166/kjg.2016.67.4.207
31. Ling CR, Wang MJ, Zhuang W. Capsule retention for 7.5 years in Meckel's diverticulum. *Dig Endosc* 2017; 29: 386-387. DOI: 10.1111/den.12795
32. Garcia-Compean D, Jimenez-Rodriguez AR, Del Cueto-Aguilera AN et al. Meckel's diverticulum diagnosis by video capsule endoscopy: A case report and review of literature. *World Journal of Clinical Cases* 2018; 6: 791-799. DOI: 10.12998/wjcc.v6.i14.791
33. Cano-Valderrama O, Manso B, Ruiz-Tovar J et al. Retained Capsule Endoscopy in a Patient with a Meckel Diverticulum Previously Treated by Endovascular Embolization. *American Surgeon* 2018; 84: E33-E35.
34. Lin L, Liu K, Liu H et al. Capsule endoscopy as a diagnostic test for Meckel's diverticulum. *Scand J Gastroenterol* 2019; 54: 122-127. DOI: 10.1080/00365521.2018.1553353
35. Ostrowski S, Whitfield A, Stevenson T et al. Randomised controlled trial of early capsule endoscopy versus colonoscopy following negative gastroscopy in acute gastro-intestinal bleeding. *United European Gastroenterology Journal* 2019; 7(8 Supplement): 134. DOI: <https://dx.doi.org/10.1177/205064061985467>
36. Kang B, Jung JH, Park JY et al. Retention of a Wireless Endoscopic Capsule in the Meckel Diverticulum of a 12-Year-old Boy. *J Pediatr Gastroenterol Nutr* 2020; 71: e72. DOI: 10.1097/mpg.0000000000002723
37. D'Souza SM, Mussarat S, Parekh PJ. S1740 Lost in Space: Video Capsule out of Orbit Causing a Colo-Vaginal Fistula. *Official journal of the American College of Gastroenterology | ACG* 2020; 115: S898-S899. DOI: 10.14309/01.ajg.0000709008.13648.2b

38. Saad MK, Fiani E, El Hajj I et al. A rare complication of capsule endoscopy, retained in diverticula: A report of two cases. *International Journal of Gastrointestinal Intervention* 2021; 10: 36-39. DOI: 10.18528/ijgii200023
39. Rey M, Cuello E, Sierra F. Capsule endoscopy retention in Zenker's diverticulum. *Revista Espanola De Enfermedades Digestivas* 2022; 114: 740-741. DOI: 10.17235/reed.2022.8907/2022
40. Noujaim MG, Cohn J, Sullivan BA. Capsule Retention in Meckel's Diverticulum During Evaluation for Iron Deficiency Anemia. *ACG Case Rep J* 2022; 9: e00797. DOI: 10.14309/crj.0000000000000797
41. Díaz-Alcázar MM, Aguilar-Cruz I. Is intestinal diverticulosis a risk factor in video capsule endoscopy? *Rev Gastroenterol Mex (Engl Ed)* 2022; 87: 390-392. DOI: 10.1016/j.rgmexen.2022.05.013
42. Cheah A, Martin N, Saad N. A rare case of video capsule retention. *Journal of Gastroenterology and Hepatology* 2022; 37(Supplement 1): 188-189. DOI: <https://dx.doi.org/10.1111/jgh.15955>
43. Aabakken L, Blomhoff JP, Jermstad T et al. Capsule endoscopy in a patient with Zenker's diverticulum. *Endoscopy* 2003; 35: 799. DOI: 10.1055/s-2003-41596
44. Rezapour M, Amadi C, Gerson LB. Retention associated with video capsule endoscopy: systematic review and meta-analysis. *Gastrointest Endosc* 2017; 85: 1157-1168.e1152. DOI: 10.1016/j.gie.2016.12.024
45. 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: 352-376. DOI: 10.1055/s-0034-1391855
46. Biondi A, Persiani R, Vigorita V et al. Education and imaging: gastrointestinal: videocapsule retention: rationale for surgical indication. *J Gastroenterol Hepatol* 2011; 26: 608. DOI: 10.1111/j.1440-1746.2011.06618.x

