

# Video capsule colonoscopy in routine clinical practice

Ervin Toth<sup>1</sup>, Diana E. Yung<sup>2</sup>, Artur Nemeth<sup>1</sup>, Gabriele Wurm Johansson<sup>1</sup>, Henrik Thorlaciuss<sup>3</sup>, Anastasios Koulaouzidis<sup>1,2</sup>

<sup>1</sup>Department of Gastroenterology, Skåne University Hospital, Lund University, Lund, Sweden; <sup>2</sup>Endoscopy Unit, The Royal Infirmary of Edinburgh, Edinburgh, UK; <sup>3</sup>Department of Surgery, Skåne University Hospital, Lund University, Lund, Sweden

*Contributions:* (I) Conception and design: All authors; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: E Toth, A Nemeth, G Wurm Johansson; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

*Correspondence to:* Dr. Ervin Toth. Department of Gastroenterology, Skåne University Hospital, Inga Marie Nilssons gata 49, 205 02 Malmö, Sweden. Email: ervin.toth@med.lu.se.

**Background:** Colon capsule endoscopy (CCE) offers direct mucosal visualisation without sedation or gas insufflation required in conventional colonoscopy (CC). However, evidence for the role of CCE as an adjunct or alternative to CC remains equivocal. In this observational cohort study, we report our experience of using CCE to investigate patients with suspected colon pathology at a tertiary referral centre.

**Methods:** From 2007–2015, consecutive patients requiring colonoscopy were recruited from a tertiary care centre in Malmö, Sweden. Data collected: patient demographics, indication for CCE, findings, bowel cleansing, colon transit time (CTT) and completeness of colon examination.

**Results:** Seventy-seven patients (57 F/20 F, median age 56 years) were included. The reason for CCE was previously incomplete or refused CC in 39 and 26 cases, and follow up of previous findings in 12 cases, respectively. The main clinical indications were gastrointestinal (GI) bleeding (n=28; 36%) and suspected inflammatory bowel disease (IBD) or follow-up of known IBD (n=23; 30%). CCE was complete in 58/77 (75%) patients. In 3 patients the colon was not reached; in the other 16, the capsule reached the rectum (n=4), sigmoid (n=6), descending colon (n=5) and transverse colon (n=1). Findings were: normal CCE (n=15; 19%) colonic diverticula (n=29; 38%), polyps (n=17; 22%), active IBD (n=12; 16%), haemorrhoids (n=8; 10%), colonic angioectasia (n=4; 5%) and cancer (n=1; 1%). Small-bowel findings were recorded in 8 (10%) patients. All patients tolerated bowel preparation and CCE well. Two patients with an ulcerated small-bowel stricture and cancer respectively experienced temporary capsule retention with spontaneous resolution.

**Conclusions:** CCE is a well-tolerated alternative to CC, but requires technological improvement and optimisation of clinical practice to meet current reference standards. Although further technical development is required, CCE may complement or even replace CC for certain clinical indications.

**Keywords:** Colon capsule endoscopy (CCE); capsule colonoscopy; gastrointestinal (GI) bleeding; inflammatory bowel disease (IBD); colorectal cancer (CRC)

Submitted Mar 05, 2017. Accepted for publication Mar 20, 2017.

doi: 10.21037/atm.2017.03.91

View this article at: <http://dx.doi.org/10.21037/atm.2017.03.91>

## Introduction

Since introduced into routine clinical practice in the late 1960s, conventional or optical colonoscopy has become the gold standard for the investigation of colon diseases. It has proven invaluable for colorectal cancer (CRC) screening

and inflammatory bowel disease (IBD) diagnosis and surveillance amongst other clinical applications. However, conventional colonoscopy (CC) remains an invasive, labour- and resource-intensive procedure which is associated with certain risks and adverse events, including perforation,

haemorrhage and the risks associated with sedation or even anaesthesia if required (1,2). Furthermore, it is an uncomfortable, undignified experience for many patients with several points of contention, from the procedure itself to the laxative bowel preparation required beforehand (1). This has been shown to discourage and limit patient uptake of colonoscopic investigation and treatment. In an audit of the British national bowel cancer screening programme, up to 10% of patients experienced significant discomfort during colonoscopy, with about 35% of patients reporting some discomfort from the procedure (3,4). A systematic review by Doyle *et al.* has shown that patient experience is positively associated with clinical effectiveness and patient safety (5). The current uptake of CRC screening remains lower than ideal (6) and patient comfort and acceptance should therefore not be overlooked.

Although computed tomography (CT) colonography has been used as an alternative in patients unable or unwilling to undergo CC, it is less accurate (7-9) and does not offer direct visualisation of the bowel mucosa. Capsule endoscopy (CE) has been adopted as the prime modality for non-invasive small bowel imaging (10). Likewise, colon CE (CCE) has recently been developed to fulfil a similar role, offering the advantages of direct mucosal visualisation without the need for sedation or gas insufflation (11). The European Society of Gastrointestinal Endoscopy (ESGE) has determined that CCE is generally feasible, safe and accurate for use in patients with incomplete colonoscopy, and although it acknowledges the current lack of sufficient evidence, it allows that CCE may have a role in IBD surveillance (12). The current evidence for the role of CCE as an adjunct or alternative to CC remains equivocal (2,13-15). Therefore, in this observational cohort study, we report our clinical experience of using CCE to investigate patients with suspected colon pathology at a tertiary referral centre in Sweden.

## Methods

From November 2007 to November 2015, consecutive patients with incomplete CC or who had refused further investigation with colonoscopy were recruited from a tertiary care centre in Malmo, Sweden. Full informed consent was obtained from these patients who underwent CCE using the PillCam® COLON 1 (CCE-1; Given® Imaging Ltd., Yokneam, Israel) and 2 (CCE-2; Covidien, Minneapolis, USA). As per local protocol patients undertook a low residue diet for 3 days prior to CCE with

a clear liquid diet on the day before. The evening before the examination, patients ingested 3 L of polyethylene glycol (PEG) solution, followed by an additional 1 L on the morning of the procedure. The patient then swallowed the capsule. When the capsule was seen in the small bowel using the real-time viewer, the patients were given a booster dose of 30 mL of sodium phosphate (NaP) solution with 1 L of water. Further progression of the capsule was followed throughout the examination using the Rapid Access real-time viewing system. If the capsule was not excreted within 3 h of the first booster dose of NaP, a second booster dose of 15 mL NaP in 0.5 L water was provided. After another 2 h, if the capsule was still not expelled, a further 10 mg bisacodyl suppository was administered. The bowel preparation schedule is detailed in *Table 1*.

Data collected were: patient demographics (age, gender), indication for CCE, CCE findings, bowel cleansing, colon transit time (CTT) and completeness of colon examination. A complete CCE examination was defined as natural excretion of the capsule, as per Spada *et al.* (11). Results are reported as median (range) for continuous data and percentages for discrete data.

## Results

Over the study duration, a total of 77 consecutive patients (57 females, 20 males) with suspected colon pathology were included. The median age of the group was 56 years (range, 15-89 years). Thirty-nine patients had had a previously incomplete CC and 29 patients had declined CC. The main clinical indications were gastrointestinal (GI) bleeding (n=28; 36%) and suspected IBD or follow-up in patients with known IBD (n=23; 30%); other indications included abdominal pain/diverticular disease (n=18; 23%), CRC screening (n=3), follow up of abnormal radiology (n=3) and follow up after polypectomy (n=2). Patient characteristics in our group are summarised in *Table 2*.

Colon examination was complete in 58/77 (75%) patients with a median CTT of 257 min (range, 3-895 min). CCE was conducted using CCE-1 in 42 patients and CCE-2 in 35. Completion rates were similar: 32/42 (76%) using CCE-1 and 26/35 (74%) using CCE-2. The capsule did not reach the colon in 3 patients due to stomach retention, retention at a small-bowel stricture and slow small bowel transplation (SBT). In the remaining 16 incomplete examinations, the capsule reached the rectum (n=4), sigmoid (n=6), descending colon (n=5) and transverse colon (n=1). Good or excellent bowel preparation was achieved in

**Table 1** Bowel preparation regime used for patients undergoing CCE at our centre

Day	Time	Action
Days 2 to 4	All day	Low residue/fiber diet
Day 1	All day	Clear liquid diet
	Evening	3 L PEG
Day of CCE	Morning	1 L PEG
	9:00 AM	Capsule ingestion
	>1 h post ingestion	40 mg domperidone tablet if capsule delayed in stomach
	SB detection by real time viewer	Booster dose 1: 45 or 30 mL NaP and 1 L water
	3 h after booster dose 1	Booster dose 2: 30 or 15 mL NaP and 0.5 L water
	2 h after booster dose 2	10 mg bisacodyl suppository if capsule still in colon

CCE, colon capsule endoscopy; PEG, polyethylene glycol; NaP, sodium phosphate; SB, small bowel.

**Table 2** Patient characteristics in our study group

Characteristic	Total number of patients: 77
Median age in years [range]	56 [15–89]
Gender, n [%]	
Male	20 [26]
Female	57 [74]
Previous incomplete colonoscopy, n [%]	39 [51]
Indications for colonoscopy, n [%]	
GI bleeding	28 [36]
Evaluation of IBD	23 [30]
Abdominal pain/diverticulitis	18 [23]
CRC screening	3 [4]
Follow-up of X-ray findings	3 [4]
Follow-up after polypectomy	2 [3]

CRC, colorectal cancer; GI, gastrointestinal; IBD, inflammatory bowel disease.

58 (75%) patients. Patient outcomes are detailed in *Table 3*.

The most frequent findings were colonic diverticula (n=29; 38%), polyps (n=17; 22%; size 3–20 mm), active IBD (n=12; 16%), haemorrhoids (n=8; 10%), colonic angioectasia (n=4; 5%) and advanced cancer (n=1; 1%), *Figure 1*. Fifteen (19%) patients had no colon pathology on CCE. Furthermore, small-bowel findings were recorded in 8 (10%) patients, including stricture, angioectasia, tumours and lesions consistent with Crohn's disease (*Figure 2*). The

findings in our group are summarised in *Table 4*. All patients in our cohort tolerated the bowel preparation and the CCE procedure well. Two patients with significant pathology (ulcerated small-bowel stricture and CRC) experienced temporary capsule retention during the examination with spontaneous resolution. In both patients, the CCE was excreted within 7 days following the examination, as verified by plain abdominal X-ray.

## Discussion

CCE is currently provided by a single model of capsule, the PillCam<sup>®</sup> Colon. The first-generation CCE-1 was introduced in 2006; a main difference between the CCE and conventional small-bowel CE was the inclusion of 2 cameras enabling image capture from both ends of the capsule. The CCE-2 introduced a wider field of view of 172° for each camera, therefore achieving nearly 360° views. The CCE-2 also has adaptive frame rate to conserve battery life, taking images from 4 images per second when the capsule is immobile to 35 images per second when movement is detected (16). Currently, the ESGE recommends the use of CCE in average-risk patients where CC is contraindicated, technically impossible or strongly opposed by the patient (12). In our cohort of patients, CCE presented a viable alternative to CC; however this observational study highlights some of the limitations still inherent to the procedure.

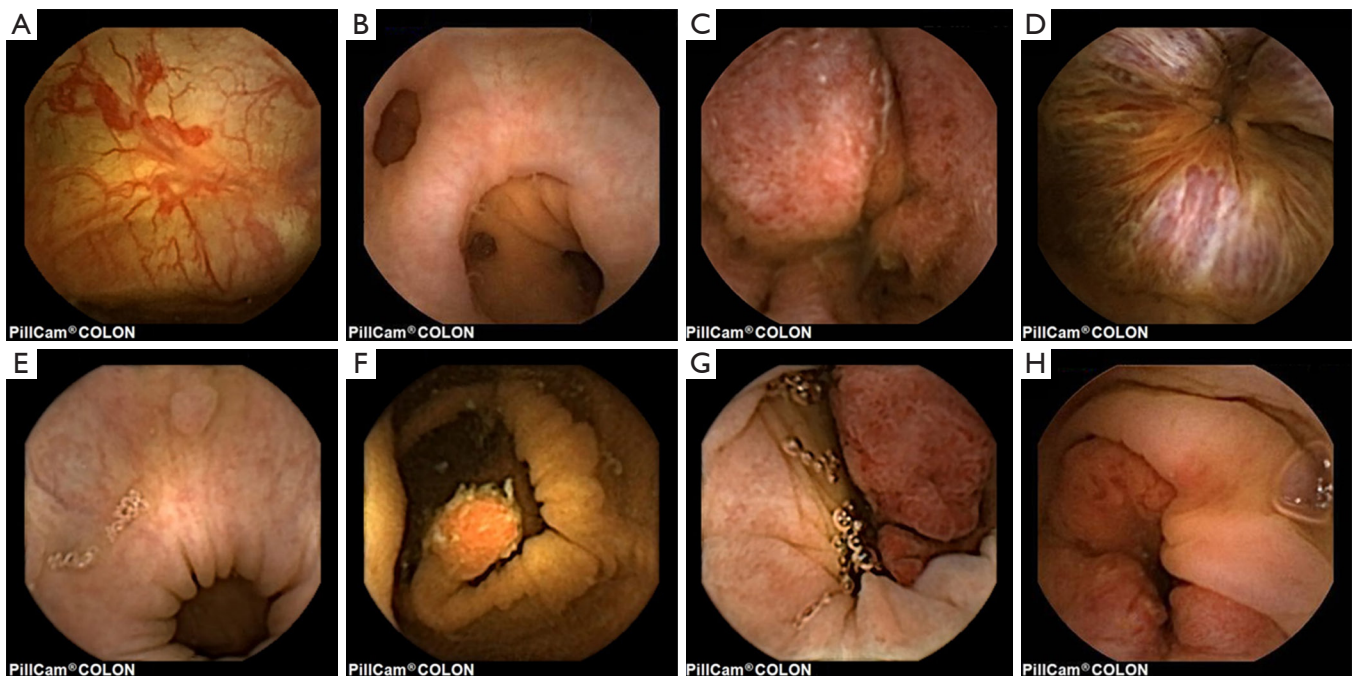
Despite the widespread use of CC, 4–20% of such examinations are incomplete, usually due to anatomical reasons (14); furthermore the discomfort involved with

**Table 3** Patient outcomes

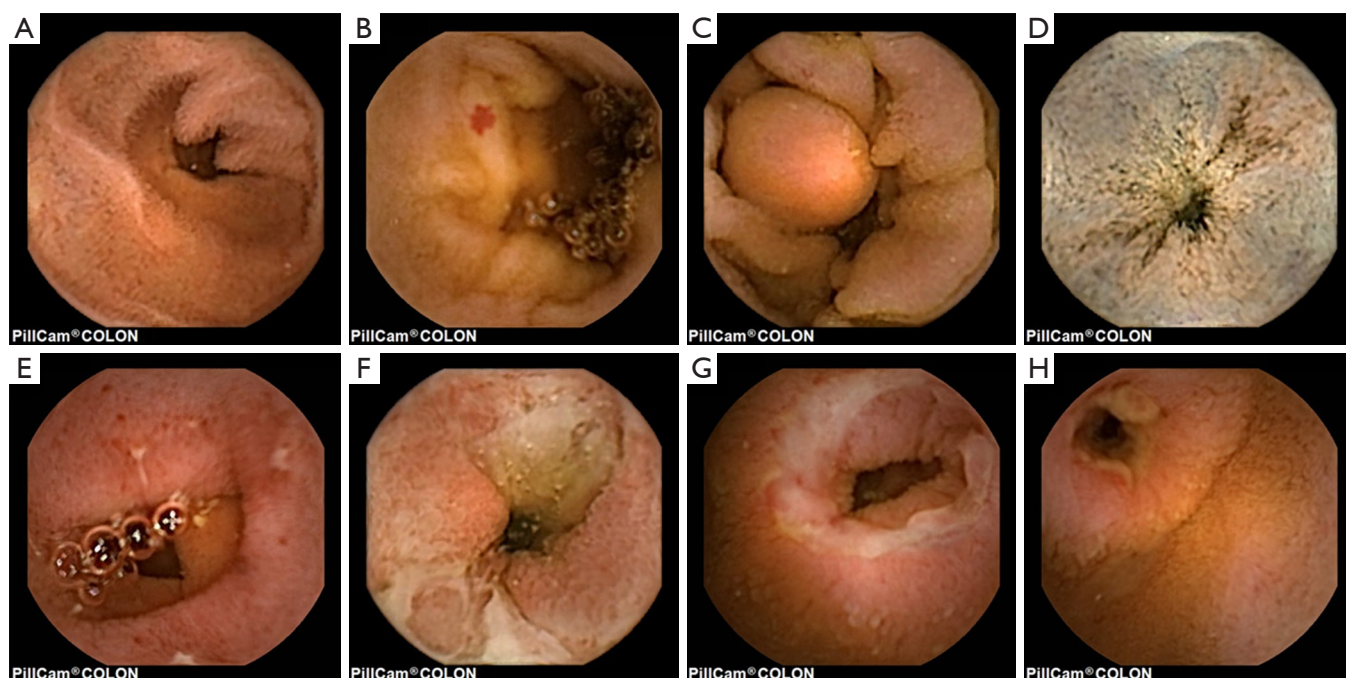
Examination details	n [%] or median [range]
Capsule model	
PillCam® COLON 1	42 [55]
PillCam® COLON 2	35 [45]
Bowel cleansing scores	
Excellent	17 [23]
Good	41 [55]
Fair	13 [18]
Poor	3 [4]
Median colon transit time, minutes [range]	257 [3–895]
Completion of colon examination	
Complete	28 [75]
Incomplete	19 [25]

such procedures could deter patients from repeat attempts where necessary. The alternative mode of investigation, CT colonography, has lower accuracy for flat lesions (14,17-19) which have been associated with increased malignant potential, whereas CCE offers direct mucosal visualisation without radiation. However, in studies using CCE-1, the sensitivity and specificity for polyps  $\geq 6$  mm were 64% and 84% respectively. Using CCE-2, sensitivity and specificity improved to 83% and 89%, with polyps as small as 6 mm detected (2).

In a meta-analysis by Spada *et al.*, the overall completion rate of examinations carried out using CCE-1 was 86.7%, improving to 90.5% using CCE-2 (20). This falls short of standard cecal intubation rates for CC. In fact, in earlier studies using CCE, the completion rate was as low as 70% (20). Interestingly, our cohort had a low completion rate of only 75%. There was no significant difference in completion rates using CCE-1 and CCE-2; however it must



**Figure 1** Capsule endoscopic images of colon. (A) Angioectasia; (B) diverticula; (C) ulcerative colitis; (D) hemorrhoids; (E) 3-mm-large diminutive polyp (hyperplastic); (F) 10-mm-large pedunculated polyp (tubular adenoma); (G) 22-mm-large sessile polyp (tubular adenoma); (H) stricturing malignant tumour (adenocarcinoma).



**Figure 2** Capsule endoscopic images of small bowel. (A) Normal; (B) angioectasia; (C) 15-mm-large submucosal tumor (lipoma); (D) tattoo; (E) Crohn's erosions; (F) Crohn's ulcers; (G) Crohn's stenosis; (H) ischemic ulcerated stenosis.

**Table 4** Colorectal and small bowel findings detected by colon capsule in our study group

Total no. of patients: 77	Findings, n [%]	
	Colorectal	Small bowel
Normal	15 [19]	69 [90]
Diverticula	29 [38]	–
Polyps	17 [22]	–
IBD	12 [16]	3 [4]
Haemorrhoids	8 [10]	–
Angioectasia	4 [5]	3 [4]
Tumour	1 [1]	1 [1]
Ulcerated ischemic stenosis	–	1 [1]

IBD, inflammatory bowel disease.

be noted that all CCE-2 examinations in our group were performed using a lower dose of NaP (30+15 mL compared to the 45+30 mL used in the CCE-1 examinations). This change was made by our centre to reduce the risk of adverse events associated with NaP (12). Although examination was incomplete in 25% of the patients in our cohort, a

key difference between CCE and CC is that the capsule travels from proximally to distally; in 15/16 patients with incomplete CCE, the proximal colon was examined. Studies have shown that in patients with incomplete colonoscopy, the incidence of proximal CRC is increased up to 2-fold (21); furthermore there is an increased risk of missing a concurrent proximal CRC (22-24).

Nevertheless, inadequate bowel preparation and visualisation remains the biggest cause of incomplete CCE (14). Although meta-analyses have shown that laxative bowel preparation is crucial, they also quote low median rates of adequate cleansing: 78% in CCE-1 and 81% in CCE-2 (20). This is similar to the rate of adequate visualisation obtained in our cohort. At present, the ESGE suggests the use of a total of 4 L PEG, given in split doses the day before and on the day of CCE examination, as well as post-capsule ingestion NaP boosters in patients with no contraindications (12). However, the evidence to support this practice is lacking (12). Furthermore, the intensity of the bowel preparation is a strong deterrent for the wider adoption of CCE, negating the non-invasiveness of the capsule itself (15,25).

In our cohort, there were only two cases of transient

retention of the CCE. One case occurred in a patient with a small-bowel stricture, highlighting perhaps the importance of screening patients for risk of retention as one would for small-bowel CE. This will become a more pertinent issue with the wider uptake of CCE in future. There is currently limited data on the use of CCE in IBD as the majority of studies have dealt with the use of CCE in CRC screening. Overall, the sensitivity and specificity of CCE for ulcerative colitis was 89% and 75% compared to CC (14). However, it may have a role in monitoring in relatively stable patients, due to the potential of avoiding colonoscopies at certain intervals.

Limitations include the retrospective nature of this observational study, which was conducted at only a single centre. However, ours is a tertiary care centre serving a wide population in the southern part of Sweden which has about 1.3 million inhabitants, therefore providing a realistic view on the use of CCE in day-to-day clinical practice. The low numbers of patients referred for CCE roughly reflect the limited dissemination of this method amongst practising physicians in the area. Our study shows that CCE is a relatively well-tolerated alternative to CC, but requires technological improvement and optimisation of clinical practice to bring it in line with the current reference standard. A cost-benefit analysis has estimated that use of CCE for population screening would be beneficial if uptake of screening could be increased (26). Although further technical development may be needed to examine the whole colon in large numbers of patients, CCE may complement or even replace CC for certain clinical indications.

### Acknowledgments

None.

### Footnote

*Conflicts of Interest:* Dr. Yung has received grant from Dr. Falk Pharma/Core and travel support from Dr. Falk Pharma; Dr. Koulaouzidis has received European Society of Gastrointestinal Endoscopy (ESGE) Given Imaging grant, material support for research from SynMed UK, honoraria from and member of advisory board for Dr. Falk Pharma UK and travel support from Almirall & Dr. Falk Pharma; Dr. Toth has received lecture fees from Given Imaging/Medtronic; Dr. Wurm Johansson has received lecture fees from Medtronic. The other authors have no conflicts of interest to declare.

*Ethical Statement:* The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, in compliance with good clinical practice and local regulations and the study was approved by the Ethical Committee of Lund University, Sweden (approval number: 2016/412). All patients gave written informed consent prior to the examinations.

### References

1. Fisher DA, Maple JT, Ben-Menachem T, et al. Complications of colonoscopy. *Gastrointest Endosc* 2011;74:745-52.
2. Carter D, Eliakim R. PillCam colon capsule endoscopy (PCCE) in colonic diseases. *Ann Transl Med* 2016;4:307.
3. Lee TJ, Rutter MD, Blanks RG, et al. Colonoscopy quality measures: experience from the NHS Bowel Cancer Screening Programme. *Gut* 2012;61:1050-7.
4. Logan RF, Patnick J, Nickerson C, et al. Outcomes of the Bowel Cancer Screening Programme (BCSP) in England after the first 1 million tests. *Gut* 2012;61:1439-46.
5. Doyle C, Lennox L, Bell D. A systematic review of evidence on the links between patient experience and clinical safety and effectiveness. *BMJ Open* 2013;3:e001570.
6. Bujanda L, Sarasqueta C, Zubiaurre L, et al. Low adherence to colonoscopy in the screening of first-degree relatives of patients with colorectal cancer. *Gut* 2007;56:1714-8.
7. IJspeert JE, Tutein Nolthenius CJ, Kuipers EJ, et al. CT-Colonography vs. Colonoscopy for Detection of High-Risk Sessile Serrated Polyps. *Am J Gastroenterol* 2016;111:516-22.
8. Graser A, Stieber P, Nagel D, et al. Comparison of CT colonography, colonoscopy, sigmoidoscopy and faecal occult blood tests for the detection of advanced adenoma in an average risk population. *Gut* 2009;58:241-8.
9. Rosman AS, Korsten MA. Meta-analysis Comparing CT Colonography, Air Contrast Barium Enema, and Colonoscopy. *Am J Med* 2007;120:203-10.
10. 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.
11. Spada C, De Vincentis F, Cesaro P, et al. Accuracy and safety of second-generation PillCam COLON capsule for colorectal polyp detection. *Therap Adv Gastroenterol*

- 2012;5:173-8.
12. Spada C, Hassan C, Galmiche J, et al. Colon capsule endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) Guideline. *Endoscopy* 2012;44:527-36.
  13. Friedel D, Modayil R, Stavropoulos S. Colon Capsule Endoscopy: Review and Perspectives. *Gastroenterol Res Pract* 2016;2016:9643162.
  14. Triantafyllou K, Beintaris I, Dimitriadis GD, et al. Is there a role for colon capsule endoscopy beyond colorectal cancer screening? A literature review. *World J Gastroenterol* 2014;20:13006-14.
  15. Yung DE, Rondonotti E, Koulaouzidis A. Capsule colonoscopy — a concise clinical overview of current status. *Ann Transl Med* 2016;4:398.
  16. Spada C, Hassan C, Costamagna G. Colon Capsule Endoscopy. *Gastrointest Endosc Clin N Am* 2015;25:387-401.
  17. Figueiredo PN, Figueiredo IN, Prasath S, et al. Automatic Polyp Detection in Pillcam Colon 2 Capsule Images and Videos: Preliminary Feasibility Report. *Diagn Ther Endosc* 2011;2011:182435.
  18. Rondonotti E, Borghi C, Mandelli G, et al. Accuracy of capsule colonoscopy and computed tomographic colonography in individuals with positive results from the fecal occult blood test. *Clin Gastroenterol Hepatol* 2014;12:1303-10.
  19. Spada C, Hassan C, Barbaro B, et al. Colon capsule versus CT colonography in patients with incomplete colonoscopy: a prospective, comparative trial. *Gut* 2015;64:272-81.
  20. Spada C, Pasha SF, Gross SA, et al. Accuracy of First- and Second-Generation Colon Capsules in Endoscopic Detection of Colorectal Polyps: A Systematic Review and Meta-analysis. *Clin Gastroenterol Hepatol* 2016;14:1533-43.
  21. Brenner H, Chang-Claude J, Jansen L, et al. Role of colonoscopy and polyp characteristics in colorectal cancer after colonoscopic polyp detection: A population-based case-control study. *Ann Intern Med* 2012;157:225-32.
  22. Villa NA, Pannala R, Pasha SF, et al. Alternatives to Incomplete Colonoscopy. *Curr Gastroenterol Rep* 2015;17:43.
  23. le Clercq CM, Winkens B, Bakker CM, et al. Metachronous colorectal cancers result from missed lesions and non-compliance with surveillance. *Gastrointest Endosc* 2015;82:325-333.e2.
  24. Stoffel EM, Erichsen R, Froslev T, et al. Clinical and Molecular Characteristics of Post-Colonoscopy Colorectal Cancer: A Population-based study. *Gastroenterology* 2016;151:870-8.
  25. Belsey J, Epstein O, Heresbach D. Systematic review: Oral bowel preparation for colonoscopy. *Aliment Pharmacol Ther* 2007;25:373-84.
  26. Palimaka S, Blackhouse G, Goeree R. Colon Capsule Endoscopy for the Detection of Colorectal Polyps: An Economic Analysis. *Ont Health Technol Assess Ser* 2015;15:1-43.

**Cite this article as:** Toth E, Yung DE, Nemeth A, Wurm Johansson G, Thorlacius H, Koulaouzidis A. Video capsule colonoscopy in routine clinical practice. *Ann Transl Med* 2017;5(9):195. doi: 10.21037/atm.2017.03.91