# Effects of Colon Capsule Endoscopy on Medical Decision Making in Patients With Incomplete Colonoscopies

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**BACKGROUND & AIMS:** **Colon capsule endoscopy (CCE) is an orally ingested colon imaging tool used to evaluate patients with colonic disease. We evaluated the efficacy of CCE in helping physicians make decisions about patients with incomplete conventional colonoscopies (ICCs).**

**METHODS:** **In a prospective study, we analyzed data from 34 patients with nonocclusive ICC who were eligible for CCE between May 2010 and April 2011; patients with colectomy, occlusive lesions, or inadequate bowel cleansing for the colonoscopy were excluded. Two experienced observers who were blinded to colonoscopy findings analyzed the CCE data. Four months later, medical records were reviewed to determine the effects of CCE on medical decision making. CCE was considered conclusive when the findings facilitated a medical decision.**

**RESULTS:** **Bowel cleanliness was good or excellent for 22 patients (64.7%). CCE exceeded the most proximal point reached by conventional colonoscopy in 29 patients (85.3%). CCE findings allowed formulation of a specific medical plan for 20 patients (58.8%); 12 (35.2%) had irrelevant or no lesions, so the study was concluded; 7 (20.5%) underwent polypectomy or surgery for advanced colorectal neoplasia; and 1 (3%) was treated for Crohn's disease. Inconclusive CCEs resulted from poor preparation of the bowel (n = 12) and excessively slow (n = 1) or rapid (n = 1) capsule transit.**

**CONCLUSIONS:** **CCE might be an alternative procedure to complete colon examination in patients with nonocclusive ICC.**

*Keywords:* Incomplete Colonoscopy; Colon Capsule Endoscopy; Medical Decision Making.

**See editorial on page 541.**

Cecal intubation is a recognized measure of colonoscopy quality control, and 30%–50% of advanced colorectal neoplasias are located in the proximal colon.[1–3] However, incomplete conventional colonoscopy (ICC) occurs in approximately 5% of patients in controlled studies[4] and in 10%–15% in regular clinical practice.[5–8] The main reasons for ICC are patient discomfort, angulations or fixation of colonic loops, redundant or tortuous colon, obstructing masses or strictures, severe diverticular disease, adhesions caused by previous surgery, or poor bowel preparation. A recent study showed that 4.3% of patients with ICC had advanced colorectal neoplasms that would have been missed if another diagnostic test had not been performed.[5] Consequently, an additional imaging study must be performed if conventional colonoscopy fails to reach the cecum. When ICC is due to inadequate bowel preparation, a repeat colonoscopy is recommended after thorough briefing on the bowel cleansing procedure. When ICC is due to bowel stenosis or significant looping, computed tomographic colonography (CTC) and double-balloon colonoscopy are considered the best alternative methods.[5,9,10] However, the latter procedures are not yet available in many centers.

Colon capsule endoscopy (CCE) is a new, noninvasive orally ingested colon-imaging tool that has been proposed as an alternative to conventional colonoscopy in the work-up of patients with ICC. Two CCE versions (PillCam CCE system; Given Imaging Ltd, Yoqneam, Israel) are currently available. Both have a microcamera located at each end of the capsule. The first-generation PillCam (CCE-1) allows image acquisition at a rate of 4 frames per second and a wide coverage area of 156°. The second-generation PillCam (CCE-2) device provides a higher frame rate, captures images from both ends at a rate of 35 images per second in motion, and has a larger lens angle that offers nearly 360° coverage of the colon.[11–13]

CCE has demonstrated its capability to detect polyps, tumors, and other colonic lesions in several studies.[11,14–17] A

*Abbreviations used in this paper:* CCE, colon capsule endoscopy; CTC, computed tomographic colonography; ICC, incomplete conventional colonoscopy.


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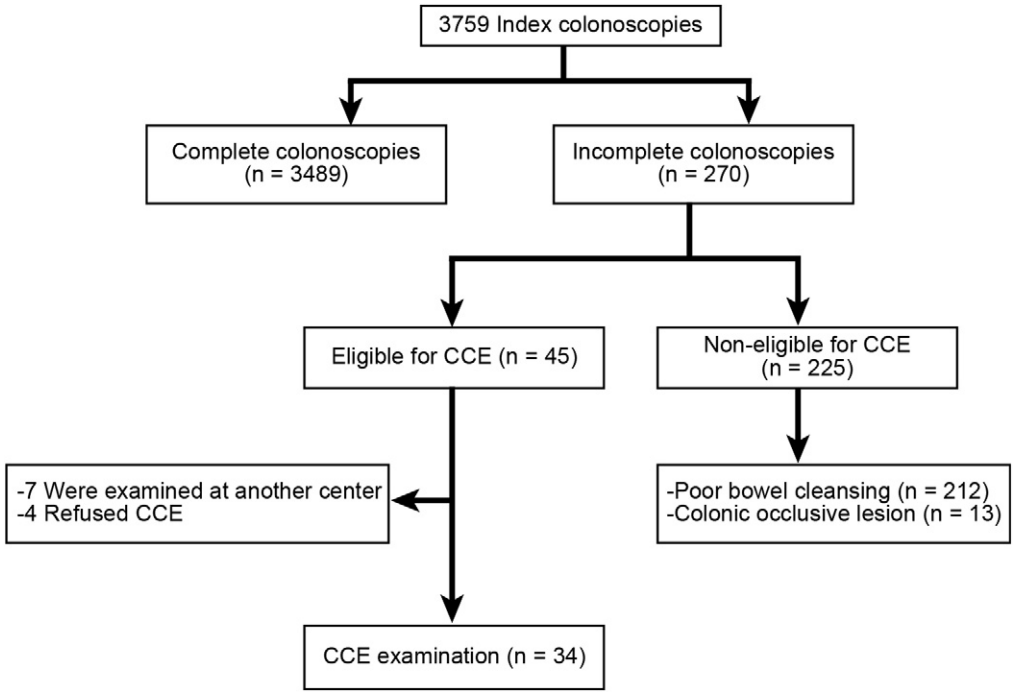


**Figure 1.** Study design (flow chart).

recent meta-analysis showed a sensitivity and specificity for detecting significant lesions (polyps 6 mm in size or ≥3 polyps of any size) of 69% and 86%, respectively.[18] Therefore, it seems a reasonable alternative method of colon examination in the setting of nonocclusive ICC.

The first report of CCE use in a patient with previous ICC was published in 2008.[19] Since then, only a small retrospective case series has been published to evaluate the utility of this technology after an ICC, but results were not conclusive.[20] Therefore, the present study aimed to investigate the impact of CCE on medical decision making in a prospective series of patients with nonocclusive ICC.

## Methods

### *Patients*

Between May 2010 and April 2011, a total of 4068 colonoscopies were performed in 3759 outpatients at the endoscopy unit of a university hospital serving an urban area with 375,000 inhabitants. Bowel cleansing and conscious sedation were performed as previously described.[21] Colonoscopy was defined as incomplete when cecal intubation was not achieved in the context of adequate bowel preparation (Boston rating scale ≥5 points).[22] During the study period 270 patients with ICC (7.1%) were prospectively evaluated to determine whether they were eligible for CCE, according to a standardized prospective algorithm (Figure 1). Patients with ICC related to occlusive bowel lesions (n = 13) were excluded for CCE, and those with fair or poor bowel preparation (n = 212) were scheduled to repeat colonoscopy, even if the reason for ICC was nonocclusive. Thus, 45 patients (16.7%) with ICC caused by looping, acute sigmoid angulation, or abdominal discomfort were eligible for CCE. Of these, 7 underwent a second examination at another center, and 4 refused CCE. Finally, 34 patients with nonocclusive ICC were examined by using CCE. Patients with abdominal discomfort were considered eligible for CCE when unbearable pain precluded continuing the procedure under conscious sedation, and deeper sedation was not feasible (in those with American Society of Anesthesiologists III physical status) or refused. The Ethics Committee of Hospital Universitario de Canarias approved the study, and all participants signed the informed consent form.

### *Capsule Protocol*

CCE was performed with the Pillcam CCE-1 device on a different day than ICC because of workflow requirements at our endoscopy unit, which operates from 8 AM to 3 PM. Bowel cleansing was performed as previously described.[15] Images were captured separately by each head of the capsule and finally combined. Anatomic landmarks were defined by using the RAPID software (Given Imaging Ltd). Thumbnail images of the cecum, hepatic and splenic flexures, rectum, and anal canal were taken as described by the manufacturer. To minimize the limitation of this technique to confirm the passage of the capsule beyond the most proximal point reached by colonoscopy, readings were performed at a speed lower than 10 frames per second by 2 observers (A.Z.G. and O.A.) who were blinded to ICC and CCE findings. To further reduce the possibility of error, a third observer (L.R.L.) made the decision in case of disagreement between the 2 main observers. These observers had extensive experience in small bowel examination and CCE use (more than 50 examinations for each procedure).

### *Data Collection*

The following variables were recorded at ICC: demographic characteristics, colonoscopy indication, use of conscious sedation, degree of bowel cleanliness,[22] depth of intubation, colonoscopy findings, and reason for failure. Regarding CCE data, the degree of cleanliness at each colon segment was recorded,[15] as were total recording time, capsule findings in

the nonvisualized and visualized parts of the colon at ICC, and adverse effects related with the preparation or the procedure itself. In patients with more than one finding, the most advanced or clinically relevant lesion was considered for clinical outcome. The level of patient satisfaction and potential procedure-related adverse effects were assessed by telephone interview 2 weeks later. Four months after CCE, clinical records were reviewed, and patients were reinterviewed to evaluate whether CCE findings determined a definitive clinical decision in the work-up. In patients with normal or inconclusive CCE, clinical records were reviewed, and a telephone interview was performed 12 months after CCE to check on health status and whether they had undergone further colon examination.

### *Definition of Criteria for Conclusive Colon Capsule Endoscopy*

CCE reading was considered conclusive when (1) all colonic segments had good or excellent cleansing, including the area previously seen by ICC, and (2) there was agreement between the observers that the capsule had exceeded the most proximal point reached at ICC, or that CCE had detected a significant lesion (tumor, polyp at least 6 mm in size, 3 or more polyps of any size, inflammatory bowel disease, and/or angiodysplasia) not previously seen by ICC.

### *Statistics*

Continuous variables are reported as mean ± standard deviation and categorical variables as percentages. Two-sided *t* test was used to compare the means of continuous variables, and the $\chi^2$ test was applied to compare categorical variables. Differences with a *P* value <.05 were considered statistically significant. Statistical analyses were performed with SPSS for Windows software, version 12.0 (SPSS Inc, Chicago, IL). Interobserver agreement on the passage of the capsule beyond the most proximal point reached by colonoscopy was tested by using kappa statistic.

## Results

In the present series, no significant difference was observed in reasons for referral between patients with complete or incomplete colonoscopy (Table 1, Supplementary Table 1). In 19 patients eligible for CCE (56%), the scope did not pass the splenic flexure at ICC. Reasons for ICC were looping in 22 (64.7%), abdominal discomfort in 7 patients (20.6%), acute sigmoid angulation in 4 (11.8%), and bradycardia in 1 patient (2.9%). Eighteen patients with ICC (52.9%) were on long-term treatment with sedatives or antidepressants, and 9 (26.5%) had undergone abdominal surgery. In those segments previously examined during ICC, no lesions were found by CCE in 21 patients (61.8%), nonadvanced polyps were found in 5 (14.7%), and 8 patients (23.5%) had diverticular disease.

### *Colon Capsule Endoscopy Data*

Table 1 describes demographic data, findings, and adverse effects in patients with conclusive or inconclusive CCE. There were no statistically significant differences in gender, age, reason for ICC, and CCE-related adverse effects between both groups. However, the proportion of patients with fair/poor bowel cleansing was significantly higher in the subgroup of patients with inconclusive CCE.

**Table 1.** Patient Characteristics, Reasons for ICC, and CCE Data

| Variables | Conclusive CCE (N = 20) | Inconclusive CCE (N = 14) | *P* value |
|---|---|---|---|
| Age (*y*), mean ± SD | 62 ± 24 | 62 ± 25 | .47 |
| Sex (female), n (%) | 14 (70.0) | 9 (64.3) | .99 |
| Patients under treatment with sedatives | 8 (40.0) | 8 (57.1) | .52 |
| Previous abdominal surgery | 4 (20.0) | 5 (35.7) | .53 |
| Reasons for ICC, n (%) | | | |
| Looping | 11 (55.0) | 11 (78.6) | .29 |
| Abdominal discomfort | 5 (25.0) | 2 (14.2) | .74 |
| Acute sigmoid angulation | 4 (20.0) | 0 (0.0) | NA |
| Bradycardia | 0 (0.0) | 1 (7.2) | NA |
| CCE data, n (%) | | | |
| Raised rectum or CCE excretion, n (%) | 17 (85.0) | 8 (57.1) | .16 |
| Adequate bowel cleansing, n (%) | 20 (100) | 2 (14.3) | <.001 |
| Irrelevant or no colonic lesions, n (%) | 13 (38.2) | — | NA |
| Advanced polyps, n (%) | 6 (17.6) | — | NA |
| CRC, n (%) | 1 (2.9) | — | NA |
| Inflammatory bowel disease, n (%) | 1 (2.9) | — | NA |
| Adverse effects, n (%) | | | |
| None | 6 (30.1) | 5 (35.7) | .98 |
| Mild symptoms[a] | 11 (55.0) | 6 (42.9) | .72 |

CRC, colorectal cancer; NA, not applicable; SD, standard deviation.
[a]Nausea, vomiting, or mild abdominal pain.

Mean capsule recording time was 318 ± 161 minutes. Bowel cleanliness was rated as good or excellent in 22 cases (64.7%). During recording time, CCE reached the rectum in 26 (77%) and was excreted in 19 patients (56%).

Interobserver agreement with regard to CCE findings was confirmed in 30 patients (91.2%) (Table 2, Supplementary Table 2). In addition, there was agreement between the 2 observers on passage of the capsule beyond the most proximal point reached by colonoscopy in 29 patients (85.3%).

The characteristics of patients with a conclusive CCE are shown in Table 2. All but 3 capsules in this group (85%) reached the rectum. In the latter patients (cases 15, 19, and 33), CCE was considered conclusive because they too had good/excellent bowel preparation, and CCE explored beyond the most proximal point reached by ICC, allowing for a final diagnosis.

Table 3 summarizes the characteristics of patients with inconclusive CCE. In 12 patients (85.7%), fair/poor bowel cleansing was the main cause of failure. Delayed gastric emptying, which exhausted the CCE battery life, and a rapid capsule transit precluded examination beyond the most proximal point reached by ICC in the 2 remaining cases. In 6 of 14 patients (42.8%) in whom the capsule did not reach the rectum, there was a concomitant reason for inconclusive CCE.

### *Medical Decision Making and Follow-up*

After a mean follow-up of 140 ± 107 days, CCE findings determined a specific medical decision in 20 of 34 patients (58.8%) (Table 4); 12 patients (35.2%) concluded work-up as CCE detected irrelevant or no lesions, 7 patients (20.5%) under-

**Table 2.** Patients With a Conclusive CCE Examination

| Patient no. | Age (*y*) | Sex | Index colonoscopy, indication | Index colonoscopy, segment reached | Reason for ICC | CCE with good–excellent cleanliness | CCE reached the rectum | CCE beyond index colonoscopy stop point | Use of sedatives | Previous abdominal surgery |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 55 | F | Hematochezia | Descending colon | Looping | Yes | Yes | Yes | No | No |
| 2 | 83 | F | Hematochezia | Sigmoid colon | Acute sigmoid angulation | Yes | Yes | Yes | No | Hysterectomy |
| 6 | 54 | M | CRC screening | Ascending colon | Looping | Yes | Yes | Yes | No | No |
| 7 | 81 | F | Suspected fistula | Sigmoid colon | Acute sigmoid angulation | Yes | Yes | Yes | No | No |
| 8 | 58 | F | CRC screening | Transverse colon | Looping | Yes | Yes | Yes | Opioids | No |
| 9 | 54 | M | Anemia | Descending colon | Looping | Yes | Yes | Yes | BDZ | No |
| 10 | 62 | F | CRC screening | Ascending colon | Abdominal discomfort | Yes | Yes | Yes | BDZ | No |
| 11 | 86 | F | Anemia | Transverse colon | Looping | Yes | Yes | Yes | BDZ | Hysterectomy |
| 15 | 51 | F | CRC screening | Transverse colon | Abdominal discomfort | Yes | No | Yes | No | No |
| 16 | 73 | F | Defecatory disorders | Descending colon | Looping | Yes | Yes | Yes | No | Hysterectomy |
| 17 | 53 | M | CRC screening | Ascending colon | Looping | Yes | Yes | Yes | No | No |
| 19 | 42 | M | CRC screening | Transverse colon | Looping | Yes | No | Yes | No | No |
| 20 | 64 | F | CRC screening | Ascending colon | Looping | Yes | Yes | Yes | BDZ | No |
| 22 | 81 | F | Cecal ulcer | Transverse colon | Looping | Yes | Yes | Yes | BDZ | No |
| 24 | 59 | F | CRC screening | Transverse colon | Looping | Yes | Yes | Yes | No | No |
| 25 | 34 | F | Anemia | Transverse colon | Abdominal discomfort | Yes | Yes | Yes | No | No |
| 29 | 73 | M | Hematochezia | Sigmoid colon | Acute sigmoid angulation | Yes | Yes | Yes | BDZ | Prostatectomy |
| 30 | 57 | M | Anemia | Sigmoid colon | Abdominal discomfort | Yes | Yes | Yes | BDZ | No |
| 32 | 67 | F | Defecatory disorders | Sigmoid colon | Abdominal discomfort | Yes | Yes | Yes | No | No |
| 33 | 66 | F | Anemia | Sigmoid colon | Acute sigmoid angulation | Yes | No | Yes | BDZ | No |

BDZ, benzodiazepine; CRC, colorectal cancer.

went polypectomy or surgery for advanced colorectal neoplasia, and 1 patient (3%) was treated for active Crohn's disease.

Follow-up of patients with inconclusive CCE 12 months after inclusion in the study revealed that 1 patient with multiple comorbidity had died, 2 patients were included in the regional colorectal cancer screening program, anemia was resolved with medical treatment in 5 patients, 3 patients underwent barium enema that proved normal, and 3 additional patients were scheduled to repeat colonoscopy (1 had normal results, 1 had ICC, and 1 refused the examination). Finally, follow-up at 12 months of 12 patients with normal or irrelevant CCE results (determined by medical record review and telephone interview) confirmed that all 12 were asymptomatic, and none had received additional colonic examinations.

**Table 3.** Patients With an Inconclusive CCE Examination

| Patient | Age (*y*) | Sex | Index colonoscopy, indication | Index colonoscopy, segment reached | Reason for ICC | CCE with good–excellent cleanliness | CCE reached the rectum | CCE passed index colonoscopy stop point | Sedative drugs | Previous abdominal surgery |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 53 | Male | CRC screening | Ascending colon | Looping | No | Yes | Yes | No | No |
| 4 | 87 | Male | Hematochezia | Ascending colon | Looping | No | Yes | Yes | BDZ | No |
| 5 | 64 | Female | CRC screening | Transverse colon | Looping | No | No | No | BDZ | Splenectomy |
| 12 | 60 | Female | CRC screening | Transverse colon | Looping | No | Yes | Yes | No | No |
| 13 | 63 | Female | Abdominal pain | Descending colon | Looping | No | Yes | Yes | No | No |
| 14 | 69 | Female | Hematochezia | Transverse colon | Discomfort | No | Yes | Yes | BDZ | No |
| 18 | 32 | Female | Abdominal pain | Descending colon | Looping | No | No | No | BDZ | Laparoscopy |
| 23 | 66 | Male | CRC screening | Transverse colon | Looping | No | No | No | Opioids | No |
| 26 | 66 | Female | Abdominal pain | Descending colon | Bradycardia | Yes | No | No | No | Hysterectomy |
| 27 | 45 | Male | CRC screening | Descending colon | Looping | No | No | Yes | BDZ | Laparoscopy |
| 28 | 66 | Female | CRC screening | Descending colon | Looping | Yes | Yes | Yes | Opioids | Hysterectomy |
| 31 | 55 | Female | Polyps (follow-up) | Sigmoid colon | Abdominal discomfort | No | Yes | Yes | BDZ | No |
| 34 | 69 | Male | Anemia | Transverse colon | Looping | No | No | No | BDZ | No |
| 35 | 78 | Female | Anemia | Ascending colon | Looping | No | Yes | Yes | No | No |

BDZ, benzodiazepine; CRC, colorectal cancer.

**Table 4.** Medical Decision in Patients With a Conclusive CCE Examination

| Patient | Age (*y*) | Sex | Reason for ICC | CCE findings | Medical decision | Follow-up |
|---|---|---|---|---|---|---|
| 1 | 55 | F | Hematochezia | Diverticula | Concluded study | Concluded study[a] |
| 2 | 83 | F | Hematochezia | Diverticula + polyp 8 mm (sigmoid colon) | Polypectomy | Concluded study (normal colonoscopy) |
| 6 | 54 | M | CRC screening | No lesions | Concluded study | Concluded study[a] |
| 7 | 81 | F | Suspected fistula | Hyperplastic polyp 2 mm (cecum) | Concluded study | Concluded study[a] |
| 8 | 58 | F | CRC screening | 3 polyps of 3 mm, diverticula (sigmoid colon) | Polypectomy | Polypectomy (adenomatous polyps) |
| 9 | 54 | M | Anemia | Polyp 1–2 mm (rectal) | Concluded study | Concluded study[a] |
| 10 | 62 | F | CRC screening | Polyp 2–4 mm (sigmoid colon), divertícula | Concluded study | Concluded study[a] |
| 11 | 86 | F | Anemia | Neoplasia (cecum) | Surgery | Surgery |
| 15 | 51 | F | CRC screening | Diverticula | Concluded study | Concluded study[a] |
| 16 | 73 | F | Defecatory disorders | Polyp 8 mm (descending colon) and polyp 3–4 mm (sigmoid colon) | Polypectomy | Polypectomy, 7 mm (adenomatous polyp) |
| 17 | 53 | M | CRC screening | Hyperplastic polyps (rectum), diverticula (sigmoid colon) | Concluded study | Concluded study[a] |
| 19 | 42 | M | CRC screening | 2 polyps of 5 mm (ascending colon) | Concluded study | Concluded study[a] |
| 20 | 64 | F | CRC screening | 2 polyps 4 and 3 mm (rectum) | Concluded study | Concluded study[a] |
| 22 | 81 | F | Cecal ulcer | Polyp 5 mm (rectum), diverticula | Concluded study | Concluded study[a] |
| 24 | 59 | F | CRC screening | 4 polyps, 1 of them 5 mm (descending colon) | Polypectomy | Polypectomy (adenomatous polyps) |
| 25 | 34 | F | Anemia | Ileocecal Crohn's disease | Medical treatment (adalimumab) | Medical treatment (adalimumab) |
| 29 | 73 | M | Hematochezia | Polyp 4 mm (sigmoid colon), diverticula, angiodysplasia | Concluded study | Concluded study[a] |
| 30 | 57 | M | Anemia | Diverticula | Concluded study | Concluded study[a] |
| 32 | 67 | F | Defecatory disorders | Polyp 7 mm (transverse) and 10 mm (sigmoid colon) | Polypectomy | Polypectomy (2 adenomatous polyps) |
| 33 | 66 | F | Anemia | Polyp 3 mm (cecum) + 8 mm (ascending colon) | Polypectomy | High risk (heart failure), not accepted for colonoscopy |

CRC, colorectal cancer.
[a]Patients with normal results or nonrelevant lesions were followed up by clinical record review and telephone interview 12 months after CCE to confirm that they were asymptomatic and that no further colonic examinations had been performed.

Only mild adverse events occurred during bowel preparation for CCE; 10 patients had nausea, 3 had vomiting, and 4 had mild abdominal pain, without significant differences between conclusive and inconclusive CCE groups. In no case did the symptoms preclude the performance of CCE. No complications were registered during capsule ingestion or transit period.

Most patients (95.8%) interviewed by telephone 2 weeks after CCE reported to be satisfied with the procedure. None reported any long-term secondary effects related with CCE.

## Discussion

Our study shows that CCE is a valid complementary technique for colon examination in patients with ICC not related to bowel obstructive lesions. This procedure allowed examination of the nonvisualized part of the colon at ICC in 86% of cases. The CCE findings facilitated medical decision-making, resulting in a specific treatment plan for almost 60% of patients.

The strength of this study is that consecutive patients with nonocclusive ICC were prospectively assessed following a standardized prospective algorithm to undergo CCE as complementary examination. This study was able to adequately select patients with ICC for CCE, which allowed evaluating the impact of this technique on the medical decision-making process in this condition.

The study has certain limitations. First, we did not perform tattooing of the most proximal point reached at ICC. If CCE is to be used as a complementary test for ICC, it might be advisable to use tattooing to objectively identify this point during capsule viewing. However, the feasibility of this approach has not yet been established. In cases where the capsule does not reach the rectum during recording time, it may be difficult to determine whether it passed the most proximal point reached by colonoscopy. To minimize this limitation in the present study, we considered that the examination was conclusive when agreement was reached by the 2 blinded observers. Although the required level of experience in CCE is not well established,[13] the extensive experience of the 2 observers makes errors in capsule reading unlikely. To further reduce the possibility of error, a third expert in CCE reading made the decision in cases of disagreement between the 2 main capsule readers.

Second, we used the first model PillCam CCE-1, instead of the second-generation CCE-2[11] device, because the latest-generation capsule was not available at the time we started the study. CCE-1 allowed us to complete the examination in 59% of patients with ICC and to obtain a final diagnosis in most. It is plausible that the new CCE-2 technology may enhance the performance of the first-generation device, but there are no studies to confirm this hypothesis.

To our knowledge, there are only 2 reports on the usefulness of CCE after ICC, a case report[19] and a retrospective series[20] that included 12 patients. In that series, the capsule reached the rectum in only 1 patient, and in another 6 patients it was not possible to explore the site where the ICC stopped. The authors suggested that CCE was not useful in the work-up of patients

with ICC. However, the limited number of patients and the fact that half the sample had colorectal obstructing neoplasia make these results inconclusive. Indeed, CCE should not be performed in patients harboring bowel stenosis or surgical anastomosis because of the high risk of capsule retention.[23] In the current study, patients with ICC caused by inflammatory or neoplastic stricture were not eligible for CCE and were scheduled for magnetic resonance colonography.[24] We also excluded CCE patients with ICC caused by poor bowel preparation who were scheduled to repeat colonoscopy after thorough cleansing. Therefore, we explored the effectiveness of CCE only in patients with ICC not related to occlusive disease of the colon. This subgroup of patients represented 16.6% of all patients with ICC in the current study. Under these circumstances, CCE enabled a full colonic evaluation in the majority of patients. In fact, the rectum was reached in 77% of cases, and the capsule progressed beyond the most proximal point scoped at index colonoscopy in 86% of patients. The most relevant finding of the present study was that CCE facilitated medical decision making and allowed formulating a specific plan for almost 60% of patients. The final decision led to a specific treatment plan in almost one-fourth of the patients and allowed us to conclude the work-up in the remaining patients.

A known limitation in the evaluation of CCE effectiveness is the lack of a validated scale to assess colon cleanliness,[25,26] which may influence the diagnostic yield.[27,28] In fact, an association between CCE sensitivity and level of cleanliness has been reported.[17] In our study only 65% of patients had adequate bowel preparation at all colon segments. However, despite this limitation, a medical decision was feasible in 60% of them. In this regard, it seems that enhanced bowel cleanliness for CCE would substantially improve the diagnostic yield of the test.

The work-up of patients with ICC remains a challenge. In 2006, the American Gastroenterological Association Clinical Practice and Economics Committee proposed computed CTC as the method of choice for patients with ICC.[29] However, CTC may fail to detect up to 20% of adenomas ≥6 mm.[30] Furthermore, CTC is an operator-dependent technique, and significant differences in diagnostic yield have been reported among radiologists.[31] More recently, double-balloon colonoscopy has also been proposed as a first-line technique for these patients.[9,10] However, this procedure is not yet available in many hospitals, and even in experienced hands it is also associated with cecal intubation failure that may be clinically relevant.[10] Therefore, the choice of complementary technique in patients with ICC must be individualized depending on the reason for incomplete examination at conventional colonoscopy, availability of resources, and expertise of each center.

In conclusion, the present study suggests that CCE is a safe and effective alternative procedure to complete colonic evaluation in a significant percentage of patients with nonocclusive ICC. Future prospective multicenter studies are warranted to investigate whether CCE-2 and better bowel cleanliness improve the performance of CCE in patients with ICC.

## Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Clinical Gastroenterology and Hepatology* at www.cghjournal.org, and at http://dx.doi.org/10.1016/j.cgh.2012.10.016.

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*Reprint requests*

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*Conflicts of interest*

**The authors disclose no conflicts.**

**Supplementary Table 1.** Referral Reasons for Colonoscopy in the Whole Series of Patients

| Reason for referral | Patients with complete colonoscopy (n = 3489) | Patients with ICC eligible for CCE (n = 45) |
|---|---|---|
| Colorectal cancer screening, n (%) | 1256 (35.9) | 16 (35.6) |
| Rectal bleeding, n (%) | 645 (18.5) | 7 (15.6) |
| Bowel habit change, n (%) | 523 (14.9) | 5 (11.1) |
| Iron deficiency anemia, n (%) | 570 (16.3) | 10 (22.2) |
| Colorectal neoplasia surveillance, n (%) | 436 (12.5) | 3 (6.7) |
| Miscellaneous, n (%) | 174 (4.9) | 4 (8.8) |

**Supplementary Table 2.** Interobserver Agreement on CCE Findings

| CCE findings | Agreement (%) | Kappa value | *P* value |
|---|---|---|---|
| No lesions | 91.15 | 0.68 | <.01 |
| Colorectal cancer | 100 | 0.99 | .001 |
| Polyps (any size) | 70.6 | 0.44 | .004 |
| Angiodysplasia | 91.2 | 0.72 | .001 |
| Diverticula | 94 | 0.82 | .001 |
| Miscellaneous | 97 | 0.65 | .001 |