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Accuracy of Capsule Colonoscopy in Detecting Colorectal Polyps in a Screening Population

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BACKGROUND & AIMS: Capsule colonoscopy is a minimally invasive imaging method. We measured the accuracy of this technology in detecting polyps 6 mm or larger in an average-risk screening population. **METHODS:** In a prospective study, asymptomatic subjects (n = 884) underwent capsule colonoscopy followed by conventional colonoscopy (the reference) several weeks later, with an endoscopist blinded to capsule results, at 10 centers in the United States and 6 centers in Israel from June 2011 through April 2012. An unblinded colonoscopy was performed on subjects found to have lesions 6 mm or larger by capsule but not conventional colonoscopy. **RESULTS:** Among the 884 subjects enrolled, 695 (79%) were included in the analysis of capsule performance for all polyps. There were 77 exclusions (9%) for inadequate cleansing and whole-colon capsule transit time fewer than 40 minutes, 45 exclusions (5%) before capsule ingestion, 15 exclusions (2%) after ingestion and before colonoscopy, and 15 exclusions (2%) for site termination. Capsule colonoscopy identified subjects with 1 or more polyps 6 mm or larger with 81% sensitivity (95% confidence interval [CI], 77%−84%) and 93% specificity (95% CI, 91%–95%), and polyps 10 mm or larger with 80% sensitivity (95% CI, 74%−86%) and 97% specificity (95% CI, 96%–98%). Capsule colonoscopy identified subjects with 1 or more conventional adenomas 6 mm or larger with 88% sensitivity (95% CI, 82%−93) and 82% specificity (95% CI, 80%–83%), and 10 mm or larger with 92% sensitivity (95% CI, 82%–97%) and 95% specificity (95% CI, 94%–95%). Sessile serrated polyps and hyperplastic polyps accounted for 26% and 37%, respectively, of false-negative findings from capsule analyses. **CONCLUSIONS:** In an average-risk screening population, technically adequate capsule colonoscopy identified individuals with 1 or more conventional adenomas 6 mm or larger with 88% sensitivity and 82% specificity. Capsule performance seems adequate for patients who cannot undergo colonoscopy or who had incomplete colonoscopies. Additional studies are needed to improve capsule detection of serrated lesions. Clinicaltrials.gov number: NCT01372878.

Keywords: Colon Cancer Detection; Diagnosis; Tumor; Colorectal Lesion; Neoplasm.

Capsule endoscopy is valuable for investigation of small-bowel disease, but adaptation of capsule technology to colorectal imaging is challenging. A first-generation colon capsule produced variable results, however, one influential trial showed only 74% sensitivity for cancer.[1] The first-generation capsule captured photographs at a constant 4 frames per second. The second-generation

Abbreviations used in this paper: **ADR, adenoma detection rate; CI, confidence interval; CRC, colorectal cancer; CT, computed tomography; CTC, computed tomography colonography.**

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capsule features motion detection and variable frame speed, with photographs at 4 frames per second when stationary and 35 frames per second when moving.[2,3] The angle of view of the imagers increased from 156° to 172° from first to second generation.

Two studies, each including approximately 100 patients, found second-generation capsule sensitivities of 89% and 84% for detecting patients with polyps 6 mm or larger (specificity, 76% and 64%, respectively).[2,3] For patients with polyps 10 mm or larger in size, the sensitivities were 88% in both studies, with specificities of 89% and 95%.[2,3]

The current study evaluated the second-generation capsule for detecting patients with polyps 6 mm or larger in an average-risk screening population. The study was conducted in 16 centers in the United States and Israel and was sponsored by Given Imaging, Inc (Yoqneam, Israel).

Materials and Methods

Equipment and Study End Points

The PillCam COLON 2 (Given Imaging Inc, Yoqneam, Israel) capsule was used in this study. The PillCam COLON 2 system includes the second-generation ingestible capsule, sensors attached to the abdomen that receive capsule images, a data recorder, and a software package that displays the images on a workstation and can create procedure reports.

The primary end point of this prospective study was the accuracy (sensitivity and specificity) of the PillCam COLON 2 for detecting patients with polyps 6 mm or larger compared with conventional colonoscopy. All study subjects were asymptomatic candidates for colorectal cancer screening.

Secondary end points were the accuracy of the PillCam COLON 2 for the detection of patients with polyps 10 mm or larger in size, and the incidence of adverse events with the PillCam COLON 2.

Design Overview

The study NCT number is 01372878. There were 10 US centers (2 academic, 8 private practice) and 6 (all academic) in Israel. The study was approved by the Institutional Review Boards at each center. Recruitment began in June 2011 and ended in April 2012. Patients were recruited from colonoscopy schedules (not consecutively) that listed their indication as screening. After obtaining informed consent, patients underwent the PillCam COLON 2 procedure. Capsule images were interpreted by 1 of 5 central readers who documented polyp location and measured size with a software tool. Four to 6 weeks later (after the capsule report was completed), the subjects underwent a colonoscopy. The colonoscopist was blinded to the capsule findings. During colonoscopy each polyp was photographed with an open 9-mm biopsy forceps aligned on its longest axis. The polyp then was resected and sent to pathology. Polyp location was estimated using endoscopic criteria. After colonoscope withdrawal from the subject, the capsule findings were unblinded. If the capsule had detected a polyp 6 mm or larger in size that was not seen by colonoscopy, the colonoscopist immediately repeated the colonoscopy.

Inclusion and Exclusion Criteria

Subjects were ages 50–75 years and were classified as average risk.[4] Subjects were excluded for the following reasons: a history of colorectal cancer (CRC) or polyp; any colon imaging study (colonoscopy, barium enema, or computed tomography [CT] colonography) in the previous 5 years; first-degree relative with CRC at age younger than 60 years; 2 or more first-degree relatives with CRC at any age; familial adenomatous polyposis, Lynch syndrome, or other genetic syndrome with increased CRC risk; inflammatory bowel disease; hematochezia; melena; iron deficiency with or without anemia; positive fecal blood test; known or suspected bowel obstruction; congestive heart failure; diabetes; abdominal surgery in the past 6 months unless it was considered unlikely to cause bowel obstruction; any implanted electromedical device; allergy or other known contraindication to study medicines; anticipated magnetic resonance imaging within 1 week of capsule ingestion; risk factors for capsule retention (eg, intestinal tumors, strictures, and so forth); active fistulas; chronic constipation; motility disorders; delayed gastric emptying; clinically significant renal disease; pregnant or nursing; of childbearing age and not practicing contraception; any condition deemed life-threatening by the investigator; or current participation in another trial testing an investigational drug or device.

PillCam COLON 2 Procedure

The capsule preparation consisted of 4 senna tablets (12-mg senna) at bedtime 2 days before the procedure, clear liquids the day before the procedure, 2 L of sulfate-free polyethylene glycol electrolyte lavage solution (PEG-ELS; Nulytely; Braintree Laboratories, Braintree, MA) between 7 and 9 PM the evening before ingestion, and 2 L the morning of ingestion approximately 45 minutes before capsule ingestion. After capsule ingestion at the endoscopy center, the capsule position was monitored in real time using the data recorder image display.[5] After the capsule exited the stomach, the patient ingested 6 oz of oral sulfate solution (SUPREP; Braintree Laboratories) diluted to 16 oz with water, followed by 1 L of water over the next hour. The oral sulfate solution is the first boost and propels the capsule through the small intestine and adds fluid to the colon. The investigator had the option of administering 10 mg metoclopramide orally for gastric capsule retention more than 1 hour. If the capsule was not excreted by 3 hours after ingestion of the first boost, the patient was given a second boost (3 oz oral sulfate solution diluted in water to 8 oz followed by 1 L of water over the next hour). If the capsule was not excreted by 2 hours after the second boost the patient self-administered a 10-mg bisacodyl suppository. A standard full meal was allowed after capsule excretion or beginning 2 hours after the suppository. Subjects kept a timed diary of activity and key procedure steps including capsule excretion. Subjects could leave the unit 10 hours after capsule ingestion if the capsule was not yet excreted. Subjects who left before excretion were instructed to disconnect the recorder at excretion or 12 hours after ingestion (whichever came first).

Capsule Video Reading

Images were downloaded, sent to the sponsor within 3 days, and forwarded to a central reader. Each central reader