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The Role of CT Colonography as a Screening Tool for Colorectal Cancer

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Abstract Most colorectal cancers (CRC) are preventable through screening and polyp removal; however, CRC remains fixed as the second leading cause of cancer mortality in the USA. This is largely due to suboptimal screening participation. This review of current literature explores the use of CT colonography (CTC), also known as virtual colonoscopy, as another option for CRC screening. Relevant recent research topics include exploring the elimination of pre-procedure colon cleansing, the extension of recommended CTC screening intervals, the implications of extracolonic findings, and the significance of CTC radiation dose in a benefit/risk analysis. Peer-reviewed literature supports CTC as a viable option to safely screen average and moderate risk patients for CRC with polyps and cancer detection rates comparable to optical colonoscopy. CTC has the potential to raise CRC screening rates in population health management efforts.

Keywords CT colonography · Virtual colonoscopy · Colonoscopy · Stool tagging · Colorectal cancer · Colon cancer screening · CT colonoscopy risk/benefit · Population health screening

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Introduction

CT colonography (CTC), also known as virtual colonoscopy, is an imaging exam produced from antithetical computed tomography (CT) images of the colon. The objective of the exam is to evaluate both intraluminal and extraluminal aspects of the colon and rectum for pathology, specifically polyps and/or colorectal neoplasms. Views consist of both two and three-dimensional images. The 3-D view is a "virtual" view similar to the traditional optical colonoscopy (OC) endoscopic views. Several single site studies were conducted in the 1990s demonstrating the efficacy of the exam, but failed to achieve widespread acceptance in the medical community. In 2008, a 15-site multicenter randomized clinical trial was conducted by the American College of Radiology Imaging Network (ACRIN) and sponsored by the National Cancer Institute and the National Institute of Health. This trial involved 2600 screening participants age 50 and older. It confirmed CTC could be performed using a standardized format by multiple radiologists with statistically significant results. The ACRIN results satisfied acceptable screening sensitivity and specificity rates (sensitivity 90%+/− 3, specificity 86%+/−2) for lesions 10 mm or greater in size [1]. This multi-centered trial found CTC to be comparable to optical colonoscopy (OC), the colorectal cancer (CRC) screening gold standard. The ACRIN study results propelled CTC into mainstream consideration by the American Cancer Society (ACS), the American Gastroenterological Association (AGA), healthcare advocacy groups, and several other medical societies [2]. Numerous commercial insurance companies began approving CTC as a screening option as opposed to an "investigational tool" only to be used under certain circumstances in which traditional optical colonoscopy was not an option. Continued review of the accuracy and benefits vs. risks of CTC and other available screening options resulted in the June 2016 "Classification A"

recommendation by the US Preventive Services Task Force (USPSTF) to the Center for Medicare Services (CMS). This recommendation strongly urges facilities to include CTC as a colorectal screening option for average and moderate risk asymptomatic patients [3••]. Despite the growing evidence over the past 7 years in support of the benefits of CTC, CMS has not reconsidered their 2009 decision not to provide national coverage for CTC screenings of Medicare patients. This review explores the current role of CTC as a screening tool for CRC.

Indications Similar to optical colonoscopy, CTC is appropriately used in screening asymptomatic average and moderate risk patients starting at age 50, as per the USPSTF and American Cancer Society recommendations for general screening [4]. OC and CTC are the only options for screening with potential to prevent cancer by detecting polyps. Other screening options, including fecal immunochemical test for blood (FIT) testing, DNA testing, and guaiac testing, were designed to detect cancers, not pre-cursor cancerous polyps [1, 5, 6••]. OC, although reimbursed by the CMS, is not always preferred or chosen by screening candidates. Prior patient surveys have found reluctance due to a variety of reasons including cultural stigmatisms, fear of anesthesia and/or invasive testing, taking off work for the exam, and challenges with necessary assisted transportation post exam [7, 8]. Guidelines by the USPSTF and many commercial insurers agree CTC "should be offered as an additional option" to screening candidates [3••].

CTC is not an appropriate screening exam for high-risk patients (inflammatory bowel disease, lynch syndrome, polyposis syndromes, etc.). Polyps commonly inherent to these high-risk screening candidates either have characteristics for which CTC is not sensitive in detecting or the number of expected polyps requiring polypectomy is extremely high, and therefore OC is likely to be needed anyway [9, 10]. Surveillance screening by CTC is however indicated in patients with prior CRC in certain clinical settings [11, 12]. The use of IV contrast with CTC is not a requirement for a screening examination, but more appropriate in special clinical settings requiring a diagnostic CTC and evaluation of other abdominal organs.

Accuracy As previously mentioned, the ACRIN trial confirmed sensitivity of CTC in detecting lesions greater than or equal to 10 mm; but how does CTC perform with polyps under 10 mm? The standard for sensitivity in polyp detection size is set by OC and based on the well-known natural history of CRC transforming from a polyp (Online Resource 1). OC can detect polyps as small as 6 mm with high sensitivity. Is this the required threshold in polyp size for accuracy in detection? Past studies on polyp transformation determined the prevalence of carcinoma within a polyp is directly related not only to the type of polyp, but the size of the polyp [13]. Two large studies, the US Clinical Outcomes Research Initiative (CORI), a data base of 13,992 patients; and a multicenter Korean study of 17,834 in concert, reported a low 0.03% cancer rate in diminutive polyps [14, 15]. Commensurate with those findings, Butterly et al., in evaluating 3192 asymptomatic screening candidates with Optical Colonoscopy and polyp removal, found carcinoma in only 0.9% of 5–10 mm polyps, and 0% of diminutive polyps [16]. Seven CTC studies published from January 1, 2008 to December 31, 2014 found sensitivity and specificity in detecting adenomas 6 mm or larger, again comparable with OC (sensitivity ranging from 73% [95% CI, 58–84%] to 98% [95% CI, 91–100%]; specificity ranging from 89% [95% CI, 84–93%] to 91% [95% CI, 88–93%]). The variability was thought to be related to variance in both the CTC protocols and the research design [1, 6••]. These studies are predominantly supportive of CTC as an appropriate screening exam if the standard threshold is capable of detecting lesions 6 mm and greater in size.

The accuracy of CTC in detecting diminutive polyps (polyps less than 6 mm) is not as sensitive as OC. Does that make CTC less appropriate for screening? Not according to studies which argue that, given the low rate of cancer prevalence in diminutive polyps, surveillance of those polyps is an appropriate management strategy [1]. In 2005, Zalis et al. published a management strategy for CTC findings which included diminutive polyps [17]. This strategy was called the CT Colonography Reporting and Data System (C-RADS) (Table 1). C-RADS was a proposal for standardized reporting of CTC findings with a recommendation scheme including surveillance, not polypectomy, for diminutive polyps. This recommendation was based on earlier data and principles of polyp transformation. Additional documented research was needed. In 2011, Kim and Pickhardt explored alternative strategies for managing the "diminutive polyps" via surveillance. Their study, supportive of this management strategy, demonstrated that the pathologic results of polypectomy for diminutive polyps did not result in a management change [18]. Later, Kim and Pickhardt reviewed negative CT screening cases (those with polyps less than 6 mm) 5–10 years after their initial CT screening and demonstrated additional support of this management strategy for diminutive polyps [19••]. In 2014, Pooler and associates reported the retrospective review of 7 years of data from 6769 screening exams with outcomes categorized utilizing the C-RADS classification [20]. Their results reinforced the literature on polyp size and relevance to management of diminutive polyps with surveillance. Findings were also commensurate to detection rates expected with OC, including the prevalence rates of advanced neoplasia [21]. C-RADS is structured reporting language supported by the ACR. Plans are underway to require use of C-RADS in the ACR's national registry data collection program to ensure quality and consistency in reporting on CTC exams [22••].

Table 1 Categorization and management recommendations for colonic findings

C0	Inadequate study/awaiting prior comparisons
	• Inadequate prep: cannot exclude lesions ≥10 mm because of presence of fluid/feces
	• Inadequate insufflation: one or more colonic segments collapsed on both views
	• Awaiting prior colon studies for comparison
C1	Normal colon or benign lesion; continue routine screening[a]
	• No visible abnormalities of the colon
	• No polyp ≥6 mm
	• Lipoma or inverted diverticulum
	• Non-neoplastic findings (e.g., colonic diverticula)
C2	Intermediate polyp or indeterminate finding: surveillance colonoscopy recommended[b]
	• Intermediate polyp 6–9 mm, <3 in number
	• Indeterminate findings, cannot exclude polyp ≥6 mm in technically adequate scan
C3	Polyp, possibly advanced adenoma: follow-up colonoscopy recommended
	• Polyp ≥10 mm
	• ≥3 polyps, each 6–9 mm
C4	Colonic mass, likely malignant: surgical consultation recommended[c]
	• Lesion compromises bowel lumen, demonstrates extracolonic invasion

This system was established by Zalis et al. and supported by CT Colon Cancer Committee: Yee J, Chang KJ, Dachman AH, Kim DH, McFarland EG, Pickhardt PJ et al. The Added Value of the CT Colonography Reporting and Data System. J Am Coll Radiol. 2016;13(8):931–5. doi:10.1016/j.jacr.2016.04.031., with permission from the American College of Radiology ®

[a] Every 5 to 10 years

[b] Evidence suggests that surveillance can be delayed at least 3 years, subject to individual patient circumstance

[c] Communicate to referring physician as per accepted guidelines for communication, such as the ACR Practice Guideline for Communication: Diagnostic Radiology. Subject to local practice, endoscopic biopsy may be indicated

Recent accuracy concerns raised by the CMS were specific to screening the Medicare-aged population. Multiple studies have found no statistically different detection rate in the Medicare population as compared to younger ones. For example, the 2012 study by Cash, which evaluated over 1400 Medicare-aged patients, demonstrated outcomes comparable to OC [23]. Also, John and associates conducted the National CT Colonography trial involving Medicare patients and again demonstrated accuracy results comparable to OC [5]. Regge et al. also conducted a randomized clinical trial of population screening comparing CTC to sigmoidoscopy in the Medicare population and found performance rates better in CTC [24].

Additional challenges in polyp detection accuracy by CTC are focused on specific polyp subgroups such as serrated polyps, flat polyps, or carpet lesions. Serrated polyps classified as sessile serrated adenomas (SSA) or traditional serrated adenomas (TSA) are cancerous precursors for many sporadic CRCs [25]. Accuracy of detecting serrated polyps is exceptionally important given that these lesions are thought to be more difficult to detect with any screening exam, including OC, as they blend with the mucosa, have flattened morphology and a mucin covering. In 2016, Kim et al. reported the ability to detect serrated polyps with a prevalence of 3.1% (254 of 829 screening patients) comparable to OC [26]. This was allowing for the exclusion of polyps less than 6 mm in their study, which is standard of practice for CTC. Flat polyp detection rates by CTC have also been found to have a sensitivity rate equivalent to OC [27•]. Sakamoto's study of 460 polyps in 2012 found detection rates ranged from 80 to 87.5% in flat polyps 6 mm or greater [28]. More studies are needed, however, to validate consistent detection rates. Lastly, carpet lesions (laterally spreading lesion ≥3 cm) were evaluated by CTC in 2014 and found to be effective at depicting 18 carpet lesions in 18 patients out of 9152 with no false positives [29]. Carpet lesions were again confirmed as detectable in CTC studies by Coppola et al. in 2014 and in 2007 by Park et al. [27•, 30]. A common factor noted in several CTC studies leading to increased conspicuity of these difficult lesions is by optimizing the preparation. By combining a cathartic, to cleanse the colon, and an oral barium, to coat the frequently subtle lesions, experienced radiologists can increase their accurate detection rates of these more challenging polyps.

Exam Preparation

CTC and OC share similarities in the need for dietary modification and bowel cleansing with a laxative prior to the exam. The laxative is a large dis-satisfier among many screening candidates and has been shown to cause avoidance by

screeners for routine CRC screening exams [31•, 32]. Large-volume polyethylene glycol (PEG) (4 L) is commonly used for OC and results in significant residual fluid. Therefore, saline cathartics, such as sodium phosphate or magnesium citrate, are preferred for CTC. In 2008, high-dose sodium phosphate, the first line laxative for CRC, was associated with increased risk of acute phosphate nephropathy [7]. Borden et al. found magnesium citrate to be as effective as high-dose sodium phosphate for CTC, especially in patients at risk for phosphate nephropathy [33]. Keedy et al. compared bowel preparation using reduced volume PEG (2 L) with single dose magnesium citrate [34]. They concluded that both laxatives provide adequate bowel cleansing and that limited bowel preparations may increase patient compliance with CRC screening. In addition to the use of laxatives in CTC, bisacodyl tablets and a suppository, or contact laxative, are also utilized for complete colon cleansing.

Slow-to-increase screening rates and candidate dissatisfaction with laxative preparations has led to ongoing attempts to decrease, if not eliminate, the cathartic laxative preparation. In 2017, a multicenter prospective trial by Utano et al. aimed to evaluate the diagnostic accuracy and patient acceptance of reduced laxative CTC in a population with a positive recent fecal immunochemical test (FIT) [31•]. They concluded that reduced laxative CTC is accurate in the detection of polypoid neoplasms 6 mm or larger, but is less accurate in the detection of non-polypoid neoplasms. Reduced laxative CTC also had a high patient acceptance and is an efficient triage examination for patients with a positive FIT.

After 2008, stool tagging became a widely accepted additional bowel cleansing technique. Stool tagging increased detection sensitivity in otherwise challenging screening exams, e.g., candidates with chronic constipation or the inability to comply sufficiently with bowel cleansing. The tagging of stool/residual fluid process requires the candidate to ingest small quantities of barium (30 ml t.i.d and/or water soluble contrast) the day before the exam. The contrast tagged stool will have a high density and therefore is easily differentiated from soft tissue density polyps. In segments of the bowel with tagged high density fluid, the polyp, if present, would appear as a filling defect.

Electronic cleansing (EC) is another technique that has potential as a future preparation option beneficial in use with screening candidates challenged with chronic constipation. A computerized algorithm "virtually cleanses" the colon of tagged fecal material, thereby allowing reduced or non-cathartic CTC. Current electronic cleansing techniques, however, produce several artifacts limiting its utility. With the advent of dual energy CT scanners in clinical practice, there has been renewed research in EC which is performed based on material decomposition capability of dual energy scanners with potential to improve the quality of EC [35, 36].

The variety of bowel preparations and a lack of standardized terminology between full and reduced catharsis have made it difficult to compare the different bowel preparation options for CTC [37]. Several studies have indicated that reduced bowel preparation for CTC is tolerated better by patients in comparison to a full bowel preparation used for OC [31•, 38, 39]. All said, neither bowel preparation, that for OC nor that for CTC, is likely to have any benefit over the other in being viewed as "favorable" by screening candidates. The benefit of bowel cleansing in both exams, however, is the opportunity for optimized efficient patient care. In the appropriate clinical context, OC and CTC can be performed for same day follow-up. OC exams may be incomplete due to anatomical obstructions, strictures, etc. thus necessitating CTC. CTC may detect a polyp which can undergo same day polypectomy by OC. In this context, CTC and OC are complimentary exams in the screening and surveillance effort.

Exam Performance

The physical steps required for the performance of a CTC exam have several advantages as a screening option to many who would otherwise not be screened safely, if at all. First, the colon is insufflated with CO2 via a short balloon tipped rectal tube using a pressure controlled mechanical insufflation device. Manual room air can also be used, but has become less common. Distention of the colon can also be accomplished by insertion of the balloon tip tube into a stoma in patient's post partial colectomies. A study comparing the two insufflation techniques found that both produced reliable colonic distention with minimal patient discomfort, but CO2 performed better in both categories [40]. Another study found both methods of insufflation to have similar patient acceptance but better colonic distention with CO2 [41]. Next, the patient is scanned in the supine and prone positions, with a scan time of less than 25 s for each position. For patients who are frail, immobile, or have severe comorbidities which prevents them from lying in the prone position, the study can be performed in the bilateral decubitus positions. The purpose of the two position scan is to move any residual stool and thereby help differentiate from the fixed position of a true polyp. Mobility of residual fluid between the two positions uncovers portions of the colonic wall previously submerged under the fluid. It also allows for a second chance to distend any segment of colon that was not distended in the first position. Patients who cannot be anesthetized, have limited mobility, have coagulopathies, etc., can usually undergo successful screening CTC exams.

Safety

Complications Complications resulting from CTC are rare; of those, colonic perforation is the most clinically significant. A review of 50,860 both asymptomatic screening patients and

symptomatic diagnostic patients indicated a total perforation rate of 0.035% [32, 42–44]. Of the total CTC perforations, 0.015% presented as symptomatic and required treatment. In comparison, OC has a symptomatic perforation rate requiring treatment ranging from 0.02 to 0.2%. The randomized clinical trial by Regge et al. comparing CTC to sigmoidoscopy in the Medicare population found complication rates were greater in sigmoidoscopy [24]. The USPSTF review of 11 randomized clinical trials also found no significant adverse results from CTC including perforation [45].

Radiation Dose In assessing the risk/benefit of CTC as a mainstream screening test, potential harm from radiation must be evaluated. The updated evidence report on CRC screening by the USPSTF published in 2016 is summarized in articles by Cardis and associates (2005) on risk of cancer with low-dose radiation and by Brenner and associates (2007) on radiation doses with CT [46, 47]. Although the USPSTF recommended CTC as a screening exam for CRC, they concluded that even though the radiation dose is small (sometimes up to 7 mSv), the cumulative radiation dose from 5-year intervals of CTC screening could "convey a small excess risk" to developing cancer [6••]. The radiation dose currently recommended by the ACR equates to half the amount of radiation used for CT scans of the abdomen (10 mSv). This dose was set by the American Association of Physicists in Medicine (AAPM), the professional organization responsible for optimizing the benefits/risks for patients undergoing medical radiation in compliance with federal and state regulations [48]. The AAPM more strongly states, "predictions of likelihood of resultant cancer incidence in those screened by CTC are highly speculative and are thus discouraged". In addition, advances in CT scanner technology since the ACRIN trial have resulted in consistently reduced radiation doses [49•, 50]. In 2011, Berrington de Gonzalez et al. conducted a risk-benefit analysis of radiation-related cancer risks from CTC screening using risk projection models based on biological effects of ionizing Radiation (BEIR) VII [51]. Benefits were found to clearly outweigh the radiation risks of developing cancer by a range of 24:1–35:1.

Extracolonic Findings An additional concern in the use of CTC is the potential harm to patients secondary to discovery of extracolonic findings. The concern has been twofold, one driven from the exposure of patients to downstream workups and the other from the potential patient distress caused by false positive findings, a factor to be considered in any screening exam. Pickhardt et al. study of 2010 (n = 10, 286) detected non-colonic malignancy in 0.35% of CTC screening examinations [52]. More recently, in 2015, Pooler and associates published the results of 7952 asymptomatic first-time CTC screening adults. Extracolonic findings were noted in only 2–3%; but 68% of those were clinically significant, e.g., malignancies and aneurysms [53••]. The USTSPF 2016 final report summarized the review of the aforementioned articles, along with 20 additional articles, stating extracolonic findings in CTC screening were common, occurring in 40–70% with 5–37% of these requiring diagnostic testing. As found in multiple studies, only ~3% needed definitive medical or surgical treatment. The treated 3% could be argued as beneficial to patients, not harmful.

Three studies from 2012 to 2014 attempted to evaluate the potential harm to patients from mental distress related to extracolonic findings of CTC screening. Plumb and associates evaluated patient and provider tolerance for incidentally discovered extracolonic findings secondary to CTC screening for CRC [54••]. They concluded that both patients and healthcare providers found the workups of incidental extracolonic findings acceptable in exchange for diagnosing an occasional malignancy. Von Wagner and associates evaluated the acceptance and psychological consequences of CTC as compared to OC in a randomized multicenter clinical trial of symptomatic patients [55]. The study looked at both short- and long-term results and found CTC more acceptable to patients in the short term and no significant difference in the long term; therefore, the harm from distress is no greater for CTC than OC per this study. Zafar et al. evaluated the utilization of CTC in the Medicare population in 2013. Their study also revealed that the elderly have increased fear and anxiety associated with more invasive forms of CRC screening and may find CTC more acceptable [56]. All in all, studies to date do not support concerns of psychological harms to screening patients greater that the current gold standard, optical colonoscopy.

Extracolonic findings can also result in increased overall costs to screening. Low cost is a core principle of screening initiatives taken into consideration by many healthcare policy makers and experts in population health management. Pyenson and associates evaluated the cost differential of CTC and OC in the Medicare population by modeling several scenarios for additional testing due to extracolonic findings, follow-up, and outcomes. Results revealed CTC to be 29% less costly than OC. The degree of cost advantage varied between scenarios, but was always positive for CTC screening [57••]. Additional action taken by the ACR to help avoid both inappropriate and potentially immense costs associated with incidental extracolonic findings was to adopt the E-RADS or extracolonic categorization schemata as an appendix to C-RADS (Table 2) [17, 20]. E-RADs is based on documented evidence-based outcomes and analysis of varied extracolonic findings and their proven management schemata. In several cases, that includes "no workup is indicated".

Patient Acceptance Acceptance/tolerance by candidates is an insurmountable factor in the success of a screening program. Prior studies have concluded the elderly have increased anxiety, fear, and discomfort associated with invasive CRC

Table 2 Categorization and management recommendations for extracolonic findings, including examples

E0	Limited examination. Compromised by artifact; evaluation of extracolonic soft tissues is severely limited.
E1	Normal results or anatomic variant. No extracolonic abnormalities visible.
	a. Anatomic variant, e.g., retroaortic left renal mass.
E2	Clinically unimportant finding. No workup indicated. Examples:
	a. Liver, kidney: simple cysts
	b. Gallbladder: cholelithiasis without cholecystitis
	c. Vertebra: hemangioma
E3	Likely unimportant finding, incompletely characterized. Subject to local practice and patient preference, workup may be indicated. Examples:
	a. Kidney: minimally complex or homogeneously hyperattenuating cyst
E4	Potentially important finding. Communicate to referring physician as per accepted practice guidelines.
	a. Kidney: solid renal mass
	b. Lymphadenopathy
	c. Vasculature: aortic aneurysm
	d. Lung: non-uniformly calcified parenchymal nodule ≥1 cm

This system was established by Zalis et al. and adopted by the American College of Radiology: Yee J, Chang KJ, Dachman AH, Kim DH, McFarland EG, Pickhardt PJ et al. The Added Value of the CT Colonography Reporting and Data System. J Am Coll Radiol. 2016;13(8):931–5. doi:10.1016/j.jacr.2016.04.031., with permission from the American College of Radiology ®

screening exams and may prefer CTC [55, 56]. Also, the elderly are more likely to have incomplete OC necessitating an alternative CRC screening exam. The 2013 study by Zafar and associates studied the utilization of CTC in Medicare patients 2 years prior to the denial of coverage in 2009 by the CMS. They concluded when CTC was reimbursable, at least 1/3 of the 10,538 asymptomatic Medicare beneficiaries chose CTC over OC. The remaining 2/3 predominantly underwent CTC due to incomplete OC. They also found that women may prefer CTC related to fear of OC, but also that provider preference may play a role in the decision [56]. Several studies have looked at the benefit of navigators in CTC compliance in the most at risk population for CRC, the low income and minority populations [58–61]. A significant increase in successful screening completion was observed and thought to be related to an improved understanding of CTC requirements by the screening candidates.

Reimbursement Incumbent to the successful role of CTC as a screening exam for asymptomatic candidates is a low to no out of pocket expense. Currently, screening colonoscopy is a covered service by many commercial insurances across the USA. It is best to confirm coverage in each local environment. Coverage determination for various insurers can be found posted online by different healthcare advocacy groups including the ACR and ACS [62•, 63]. Screening exams approved by the CMS require no co-pay from the candidate per the Affordable Healthcare Act [64]. The CMS, however, has not approved national coverage for CTC as a screening exam. Alternatively, CMS approves the use of CTC as a diagnostic tool, including surveillance, for patients unable to complete OC under specific circumstances: an obstructing neoplasm, intrinsic scarring/stricture, aberrant anatomy, obstruction from prior surgery, radiation risk, diverticular disease, extrinsic compression, or patient safety. An OC of the colon must have been attempted or there must be documentation of a patient safety issue preventing an attempt of OC before the CMS will reimburse diagnostic CTC studies [65•].

Conclusion CTC has continued to grow in acceptance in the medical community through supportive evidence-based outcomes. Although the USPSTF suggested more trials or observational studies on the significance of extracolonic findings are needed, they too found current data on CTC strong enough to support and fully recommend CTC as an exam to screen average and moderate risk candidates for colorectal cancer. CT colonography has an appeal to certain screening candidates that otherwise would not have screened and thus has a definite positive role to play in the effort to decrease the "slow to change" and unnecessarily high colorectal cancer rates and cancer deaths through screening and detection of precancerous polyps and cancers. The lack of complete financial coverage for CTC is a hindrance to its effectiveness as a CRC screening exam, but this may change as many healthcare organizations and CRC advocacy groups are uniting in petitioning CMS to allow national coverage.

Compliance with Ethical Standards

Conflict of Interest Vasantha Vasan declares that she has no conflict of interest.

Cecelia Brewington is a member of the CT Colonography Committee for the American College of Radiology.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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