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American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Colorectal Cancer Screening**

Variant 1: **Average risk (age >50 years).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray colon barium enema double-contrast every 5 years after negative screen	7		Med
CT colonography every 5 years after negative screen	6	The role of CTC in colorectal cancer screening is still being investigated	Med
X-ray colon barium enema single-contrast every 5 years after negative screen	4	If cannot perform double-contrast BE or CTC.	Med
MR colonography every 5 years after negative screen	4		None
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

Variant 2: **Moderate risk: personal history of adenoma or carcinoma or first-degree family history of cancer or adenoma.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray colon barium enema double-contrast every 5 years after negative screen	7		Med
CT colonography every 5 years after negative screen	6	The role of CTC in colorectal cancer screening is still being investigated.	Med
X-ray colon barium enema single-contrast every 5 years after negative screen	4	If cannot perform double-contrast BE or CTC.	Med
MR colonography every 5 years after negative screen	4		None
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

Variant 3: **Average risk following positive fecal occult blood test (FOBT).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray colon barium enema double-contrast	7		Med
CT colonography	6	The role of CTC in colorectal cancer screening is still being investigated.	Med
X-ray colon barium enema single-contrast	4	If cannot perform double-contrast BE or CTC.	Med
MR colonography	4		None
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

Clinical Condition: **Colorectal Cancer Screening**

Variant 4: **High risk: HNPCC.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray colon barium enema double-contrast every 1-2 years at 20, every 1 year at 40	4	Colonoscopy preferred.	Med
CT colonography every 1-2 years at 20, every 1 year at 40	4	Colonoscopy preferred.	Med
X-ray colon barium enema single-contrast every 1-2 years at 20, every 1 year at 40	3	If cannot perform colonoscopy, CTC, or double-contrast BE.	Med
MR colonography every 1-2 years at 20, every 1 year at 40	3		None
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

Variant 5: **High risk: ulcerative colitis or Crohn's colitis.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray colon barium enema double-contrast every 12 months	3	Colonoscopy preferred for ability to obtain biopsies to look for dysplasia.	Med
X-ray colon barium enema double-contrast every 24 months	3	Colonoscopy preferred for ability to obtain biopsies to look for dysplasia.	Med
CT colonography every 12 months	3	Colonoscopy preferred for ability to obtain biopsies to look for dysplasia.	Med
CT colonography every 24 months	3	Colonoscopy preferred for ability to obtain biopsies to look for dysplasia.	Med
MR colonography every 12 months	3	Colonoscopy preferred for ability to obtain biopsies to look for dysplasia.	None
MR colonography every 24 months	3	Colonoscopy preferred for ability to obtain biopsies to look for dysplasia.	None
X-ray colon barium enema single-contrast every 12 months	2		Med
X-ray colon barium enema single-contrast every 24 months	2		Med
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

Variant 6: **Average, moderate or high risk individual after incomplete colonoscopy.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray colon barium enema double-contrast	8		Med
CT colonography	8		Med
X-ray colon barium enema single-contrast	5	If cannot perform double-contrast BE or CTC.	Med
MR colonography	4		None
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

COLORECTAL CANCER SCREENING

Expert Panel on Gastrointestinal Imaging: Jay P. Heiken, MD[1]; Robert L. Bree, MD, MHSA[2]; W. Dennis Foley, MD[3]; Spencer B. Gay, MD[4]; Seth N. Glick, MD[5]; James E. Huprich, MD[6]; Marc S. Levine, MD[7]; Pablo R. Ros, MD, MPH[8]; Max Paul Rosen, MD, MPH[9]; William P. Shuman, MD[10]; Frederick L. Greene, MD[11]; Don C. Rockey, MD.[12]

Summary of Literature Review

Colorectal cancer is the second leading cause of cancer deaths in the United States. An average-risk individual has a 5% lifetime risk of developing colorectal cancer. It has long been established that detection of the disease when localized is associated with a 5-year survival rate of approximately 80%. Also, evidence has accumulated to support the concept that almost all colorectal cancers develop from benign adenomas and that, in most cases, this process is slow, requiring an average of 10 years. However, because screening involves the exposure of healthy asymptomatic individuals to tests with the potential for physical and psychological injury and imposes a financial burden on society, the decision to promote screening requires scientific evidence that mortality can be reduced relatively safely and cost-effectively. Information extrapolated from symptomatic populations is not sufficient because of the possible influence of lead-time and length-time bias. In addition, the determination of whom to screen, how to screen, and how often to screen represents a complex integration of an individual's level of risk, the performance characteristics (sensitivity, specificity), the safety and cost of the screening options, and the natural history and prevalence of the target lesions (adenomas and carcinomas).

Evidence from three randomized controlled trials in average-risk individuals (age >50 years) using fecal occult blood testing (FOBT) demonstrated a 15%-33% mortality reduction [1-3]. As the incidence of cancer was unchanged, but a shift to earlier stage cancer was observed, these studies provided support for colorectal cancer screening. Thus, it can be reasoned that a test that is capable of detecting early colon cancer with relative proficiency has the potential to reduce disease-specific mortality. A nonrandomized trial with historical controls reported a reduction in the incidence of colon cancer through the removal of adenomas [4]. A case-control study demonstrated that screening sigmoidoscopy decreased colorectal cancer mortality by two thirds for cancers within reach of the sigmoidoscope [5], and another case-control study reported a reduction in incidence of and mortality from colorectal cancer after the removal of adenomas in patients who had undergone colonic endoscopy because of symptoms [6]. Results from these case-control studies have suggested a protective effect from direct structural examination of the colon lasting 5-10 years [5,6]. The issue that remains to be clarified is the potential benefit from the various screening options, the magnitude of which is highly dependent on test sensitivity, recommended test intervals, and the necessity of detecting and removing all adenomas.

The prevalence of adenomas in the general population is 30%-50%, increasing with age. The vast majority of adenomas are under 1 cm, and these lesions remain small. Lesions <1 cm in diameter have about a 1% likelihood of containing invasive cancer. Only 1%-3% of all adenomas progress to cancer. On the other hand, adenomas >1 cm have a 10% chance of containing invasive cancer or a 25% chance of progressing to invasive cancer over 20 years [7,8]. Approximately 8% may undergo malignant degeneration within 10 years. Furthermore, individuals with a history of such neoplasms appear to have an increased probability of developing colorectal cancer in the future, whereas those who have had fewer than three small adenomas have a subsequent cancer risk similar to that of the general population.

Recent guidelines have defined colorectal cancer risk levels into three categories: average (>50 years of age), moderate (first-degree relative with a history of adenoma or carcinoma, personal history of large adenoma or carcinoma), and high (hereditary syndromes—hereditary nonpolyposis colorectal cancer and familial polyposis, personal history of ulcerative colitis or Crohn's disease). The magnitude of risk for an individual with a single first degree relative with colorectal cancer is approximately 2-3 times that of the general population [9,10]. Risk increases with the number of such first degree relatives. In addition, the development of cancer tends to occur at a younger age, depending on the age at which the relative developed a neoplasm. The degree of risk of individuals with a personal history of neoplasm is unclear because all the information on this subject was derived from the precolonoscopy era, when complete colonic clearing was not performed and, theoretically, residual synchronous lesions could have evolved. There is no evidence to indicate that the natural history of the disease in the two

[1]Principal Author, Mallinckrodt Institute of Radiology, St. Louis, Mo; [2]Panel Chair, Radia Medical Imaging, Everett, Wash; [3]Froedtert Hospital East, Milwaukee, Wis; [4]University of Virginia Health Science Center, Charlottesville, Va; [5]Presbyterian Medical Center, Philadelphia, Pa; [6]Mayo Clinic, Rochester, Minn; [7]Hospital of the University of Pennsylvania, Philadelphia, Pa; [8]Brigham & Women's Hospital, Boston, Mass; [9]Beth Israel Hospital, Boston, Mass; [10]University of Washington, Seattle, Wash; [11]Carolinas Medical Center, Charlotte, NC, American College of Surgeons; [12]University of Texas, Southwest Medical Center, Dallas, Texas, American Gastroenterological Association.

Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

moderate-risk groups differs from that of the average-risk group. The probability of an individual with a hereditary nonpolyposis syndrome developing colorectal cancer may be as high as 50%. The natural history of the disease in such individuals is uncertain. A nonrandomized controlled trial of such a population screened at 3 year intervals with double-contrast barium enema and sigmoidoscopy or colonoscopy reported a significant reduction in cancer incidence [11]. The risk of cancer in individuals with ulcerative colitis increases after the disease has been present 8-10 years and correlates with disease extent. Best estimates of risk are 5% after 10-20 years of disease and 9% per year thereafter. The risk for individuals with Crohn's colitis may be comparable. Unlike the other forms of colorectal cancer screening, screening of ulcerative colitis patients focuses on the detection of dysplasia (which may be flat and identified only by random biopsies or may be macroscopically visible) and subsequent prophylactic colectomy. There is no evidence of mortality reduction from colorectal cancer screening in these patients, although a shift to early stages has been demonstrated with annual colonoscopy.

Current Colorectal Cancer Screening Recommendations

A number of organizations—including the World Health Organization (WHO), the American Cancer Society (ACS) [12], the U.S. Agency for Health Care Policy and Research (USAHCPR) [13], and the U.S. Preventive Service Task Force (USPSTF) [14]—have issued or endorsed guidelines for colorectal cancer screening, which are presented as lists of options. For average-risk individuals the options include annual or biennial FOBT, flexible sigmoidoscopy every 5 years, double-contrast barium enema every 5 years, and colonoscopy every 10 years. More specific recommendations are made for individuals who are at increased risk for colorectal neoplasia. A discussion of the nonradiologic tests for colorectal cancer screening is beyond the scope of this document. However, of the structural tests available for colorectal cancer screening, colonoscopy currently is considered to be the most sensitive and specific for detecting colorectal polyps and cancers.

Double-Contrast Barium Enema

A recent retrospective study evaluated the diagnostic yield of double-contrast barium enema (DCBE) examinations performed for colorectal cancer screening in average-risk individuals older than 50 years [15]. The diagnostic yield was 5.1% for neoplastic lesions 1 cm or larger and 6.2% for advanced neoplastic lesions, regardless of size. These diagnostic yields fall within the lower range of those reported for screening colonoscopy (5.0%-9.5% for colonic neoplasms 1 cm or larger [16-18] and 4.6%-11.7% for advanced colonic neoplasms, regardless of size [16,18,19]. In addition, DCBE has been assessed in the evaluation of individuals with a positive FOBT and in the surveillance of individuals with one or more adenomas. All other information about the effectiveness of DCBE in colorectal cancer screening is derived from symptomatic individuals. The best data on the effectiveness of the DCBE in detecting colorectal cancer come from studies in which the imaging history of patients with colorectal cancer was reviewed. Using this methodology, the sensitivity of DCBE ranges from 75%-95% [20-22]. When considering only localized cancer, the sensitivity varies from 58%-94% [21,23]. In studies comparing DCBE to proximate endoscopy, the sensitivity has been 80%-100% [24,25], and when used to evaluate individuals with a positive FOBT, most reports indicate a sensitivity of 75%-80% [26,27]. The sensitivity of DCBE for large adenomas has been best studied when all subjects have undergone both radiologic and endoscopic procedures. With this study design, sensitivity has ranged from 45%-85% [25,28-30]. In the large study in which polypectomy was shown to reduce the incidence of cancer, most of the benefit was derived during the initial adenoma clearance. Almost one-third of the entry group was selected because of a positive barium enema.

It has been determined that the specificity of DCBE for large adenomas is 96% [25] and the negative predictive value is 98% [31]. It is frequently suggested that the DCBE is less effective at demonstrating polyps in the rectosigmoid colon. However, well-designed studies have shown that sensitivity figures for the DCBE in this anatomic region are comparable to those in other colonic sites [32]. The diagnostic yield of DCBE can be increased by supplementing it with flexible sigmoidoscopy. In the workup of a positive FOBT, the combination of the two procedures detected 98% of large polyps and cancers [26]. Whether the mortality benefit is sufficient to justify the cost, risk, and inconvenience of two tests is unknown, but that determination likely is affected by disease prevalence and risk level. As previously mentioned, screening with a DCBE and flexible sigmoidoscopy contributed to a reduction in cancer incidence in a hereditary nonpolyposis colorectal cancer (HNPCC) kindred, a group with a higher lesion distribution proximal to the reach of flexible sigmoidoscopy [11]. Cost-effectiveness analysis has demonstrated that the DCBE performed every 5-10 years costs less than $22,000 per life year saved for a possible range of natural history, far below the standard of $40,000 [33]. DCBE every 5 years costs less than $14,000 per life year saved. Even in individuals with a family history, DCBE performed every 5 years has been shown to be the most cost-effective screening strategy [34].

DCBE is a safe procedure with a perforation rate of 1/25,000 [35]. The perforation rate associated with a single-contrast barium enema (SCBE) is 1/10,000, flexible sigmoidoscopy 1/5,000, and diagnostic colonoscopy 1/2,000.

There is very little information on DCBE for cancer surveillance of patients with inflammatory bowel disease. In one study of 10 patients, DCBE identified 14/22 areas of dysplasia or cancer [36]. No information on the correct identification of patients was given. However, DCBE identified four of seven areas of dysplasia occurring in endoscopically normal mucosa, suggesting that DCBE might have a complementary role in such surveillance programs.

Single-Contrast Barium Enema

A preponderance of the literature portrays a dramatically inferior performance profile for the SCBE. However, most of these studies were performed before 1970 and were published in nonradiologic journals, or focused on patients with persistent symptoms after a normal barium enema. Recent studies suggest that SCBE has the potential to be as sensitive as DCBE for cancer and large polyps. Reported sensitivity for cancer ranges from 82%-95% [21,22] and is approximately 95% for large polyps [37]. However, because of the paucity of studies and the limitations of the study designs, questions arise about the reproducibility of the results, particularly for large polyps. In one of the FOBT trials, SCBE was used for diagnostic follow-up. The sensitivity for cancer was 80% [3]. Most authorities question the adequacy of SCBE for evaluating the rectum and recommend supplementation with sigmoidoscopy.

Computed Tomography Colonography

Computed tomography colonography (CTC) (also known as “virtual colonoscopy”) was introduced in 1994 as a noninvasive method of imaging the colon using helical CT. Except for one study that was hampered by suboptimal technique [38] and a steep learning curve, early CTC trials performed with single-detector-row CT scanners demonstrated sensitivities of 68%-92% and specificities of 82%-98% for polyps 10 mm and larger [39-45]. A meta-analysis of these early trials confirmed reasonably high pooled sensitivities by patient and by lesion of 88% and 81%, respectively, with a pooled specificity of 95% for polyps 10 mm and larger [46]. More recent studies performed with 4-detector-row scanners have demonstrated sensitivities and specificities of 82%-100% and 90%-98%, respectively, for polyps 10 mm and larger [47-50]. It is important to recognize, however, that these trials were not performed on screening populations but on individuals who were at increased risk for colorectal neoplasia. A large single institution screening trial using single-detector-row CT demonstrated individual reader sensitivities of 59%-73% and specificities of 95%-98% for polyps ≥10 mm [51]. A smaller single institution screening trial using multidetector-row CT demonstrated a sensitivity of 100% for polyps ≥10 mm and larger, but in that study only three patients had polyps of that size [52].

Three large multicenter trials comparing multidetector-row CTC and fiberoptic colonoscopy for detecting colorectal polyps and cancers have been published. In a study of 1,233 asymptomatic average-risk individuals undergoing colorectal cancer screening, the sensitivities of CTC and colonoscopy for adenomatous polyps ≥10 mm were 94% and 88%, respectively [53]. In the second study [54], which included 600 patients referred for clinically indicated colonoscopy, the sensitivities of CTC and colonoscopy for detecting patients with polyps ≥10 mm were 55% and 100%, respectively, and in the third study [28], which included 614 individuals at increased risk for colorectal neoplasia, the sensitivities of CTC and colonoscopy were 59% and 98%, respectively. Thus, in the evaluation of a screening population, CTC had a very high sensitivity and outperformed colonoscopy, whereas in the other two studies CTC had a low sensitivity, and colonoscopy outperformed CTC by a significant margin. These discrepant results may be related to differences in study design and reader experience. In the study in which CTC outperformed colonoscopy [53], the readers used a primary 3-dimensional endoluminal evaluation of the colon, whereas all other studies have used a primary 2-dimensional evaluation. In addition, that study employed stool and liquid tagging as part of the bowel preparation of all patients, whereas the other two studies did not. Furthermore, one of the other two large multicenter trials [54] suffered from inadequate reader training. Only one of the nine centers involved in that trial had substantial prior experience with CTC, and the only requirement to be a reader was performance of at least 10 CTC procedures (without any test of accuracy). For the institution in that study with prior CTC experience, the sensitivity for polyps ≥10 mm was 82%, compared with 24% for the other eight institutions.

A recent review of a one-year experience of CTC screening for colorectal neoplasia showed that 3.9% of individuals had a polyp 1 cm or larger and 6.9% had one or more polyps 6-9 mm in diameter. Of the 71 patients who chose colonoscopy for further evaluation of these polyps, concordant lesions were found at colonoscopy in 65 (91.5% positive predictive value) [55].

Currently, most third-party payers are providing reimbursement for screening CTC only after a failed colonoscopy or in some cases for individuals who have a contraindication to colonoscopy (eg, those on chronic anticoagulation or with severe chronic lung disease who are at risk for undergoing sedation). Several studies have demonstrated the usefulness of CTC in individuals who have undergone an incomplete colonoscopy [56-58] or in patients with an occlusive colon carcinoma [59].

Magnetic Resonance Colonography

Magnetic resonance colonography (MRC), which was introduced approximately 3 years after CTC, has the advantage that it does not use ionizing radiation. However, the spatial resolution of MRC is less than that of CTC, and MRC requires colonic distension with liquid (a diluted gadolinium solution for "bright lumen" [T1-weighted]) imaging or tap water for "dark lumen" (T2-weighted) imaging. Clinical studies comparing MRC with optical colonoscopy have demonstrated excellent results, with sensitivities of 93%-100% for polyps ≥10 mm [60,61]. Nevertheless, experience with MRC is extremely limited, especially outside of Europe.

Ultrasound

A study using ultrasound performed after colonic distension with rectally administered water demonstrated a sensitivity and specificity for carcinoma of 94% and 100%, respectively [62]. In that study sensitivity and specificity for polyps >7 mm were 91% and 100%, respectively. No other published reports support the reproducibility of these findings, however, and another study using the same technique reported a sensitivity of 12.5% for polyps >7 mm [63]. Experience with this technique is extremely limited, and the procedure is not recommended for colorectal cancer screening at this time.

Role of Local Expertise

Overall, the most appropriate imaging tests for colorectal cancer screening are the DCBE and CT colonography. The choice between these two tests may depend largely on local imaging expertise and on physician and patient preference.

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