

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 |

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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 |

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COLORECTAL CANCER SCREENING

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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 moderate-risk groups differs from that of the average-risk group. The probability of an individual with a hereditary

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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.

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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

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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.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

| Relative Radiation Level Designations | |
|---------------------------------------|-------------------------------|
| Relative Radiation Level | Effective Dose Estimate Range |
| None | 0 |
| Minimal | < 0.1 mSv |
| Low | 0.1-1 mSv |
| Medium | 1-10 mSv |
| High | 10-100 mSv |

References

1. Hardcastle JD, Chamberlain JO, Robinson MH, et al. Randomised controlled trial of faecal-occult-blood screening for colorectal cancer. *Lancet* 1996; 348(9040):1472-1477.

2. Kronborg O, Fenger C, Olsen J, Jorgensen OD, Sondergaard O. Randomised study of screening for colorectal cancer with faecal-occult-blood test. *Lancet* 1996; 348(9040):1467-1471.
3. Mandel JS, Bond JH, Church TR, et al. Reducing mortality from colorectal cancer by screening for fecal occult blood. Minnesota Colon Cancer Control Study. *N Engl J Med* 1993; 328(19):1365-1371.
4. Winawer SJ, Zauber AG, Ho MN, et al. Prevention of colorectal cancer by colonoscopic polypectomy. The National Polyp Study Workgroup. *N Engl J Med* 1993; 329(27):1977-1981.
5. Selby JV, Friedman GD, Quesenberry CP, Jr., Weiss NS. A case-control study of screening sigmoidoscopy and mortality from colorectal cancer. *N Engl J Med* 1992; 326(10):653-657.
6. Muller AD, Sonnenberg A. Protection by endoscopy against death from colorectal cancer. A case-control study among veterans. *Arch Intern Med* 1995; 155(16):1741-1748.
7. Muto T, Bussey HJ, Morson BC. The evolution of cancer of the colon and rectum. *Cancer* 1975; 36(6):2251-2270.
8. Stryker SJ, Wolff BG, Culp CE, Libbe SD, Ilstrup DM, MacCarty RL. Natural history of untreated colonic polyps. *Gastroenterology* 1987; 93(5):1009-1013.
9. Burt RW. Colon cancer screening. *Gastroenterology* 2000; 119(3):837-853.
10. Johns LE, Houlston RS. A systematic review and meta-analysis of familial colorectal cancer risk. *Am J Gastroenterol* 2001; 96(10):2992-3003.
11. Jarvinen HJ, Mecklin JP, Sistonen P. Screening reduces colorectal cancer rate in families with hereditary nonpolyposis colorectal cancer. *Gastroenterology* 1995; 108(5):1405-1411.
12. Smith RA, Cokkinides V, Eyre HJ. American Cancer Society guidelines for the early detection of cancer, 2003. *CA Cancer J Clin* 2003; 53(1):27-43.
13. Winawer S, Fletcher R, Rex D, et al. Colorectal cancer screening and surveillance: clinical guidelines and rationale-Update based on new evidence. *Gastroenterology* 2003; 124(2):544-560.
14. Pignone M, Rich M, Teutsch SM, Berg AO, Lohr KN. Screening for colorectal cancer in adults at average risk: a summary of the evidence for the U.S. Preventive Services Task Force. *Ann Intern Med* 2002; 137(2):132-141.
15. Kung JW, Levine MS, Glick SN, Lakhani P, Rubesin SE, Laufer I. Colorectal cancer: screening double-contrast barium enema examination in average-risk adults older than 50 years. *Radiology* 2006; 240(3):725-735.
16. Betes M, Munoz-Navas MA, Duque JM, et al. Use of colonoscopy as a primary screening test for colorectal cancer in average risk people. *Am J Gastroenterol* 2003; 98(12):2648-2654.
17. Harewood GC, Lieberman DA. Prevalence of advanced neoplasia at screening colonoscopy in men in private practice versus academic and Veterans Affairs medical centers. *Am J Gastroenterol* 2003; 98(10):2312-2316.
18. Lieberman DA, Weiss DG, Bond JH, Ahnen DJ, Garewal H, Chejfec G. Use of colonoscopy to screen asymptomatic adults for colorectal cancer. Veterans Affairs Cooperative Study Group 380. *N Engl J Med* 2000; 343(3):162-168.
19. Imperiale TF, Wagner DR, Lin CY, Larkin GN, Rogge JD, Ransohoff DF. Results of screening colonoscopy among persons 40 to 49 years of age. *N Engl J Med* 2002; 346(23):1781-1785.
20. Brady AP, Stevenson GW, Stevenson I. Colorectal cancer overlooked at barium enema examination and colonoscopy: a continuing perceptual problem. *Radiology* 1994; 192(2):373-378.
21. Johnson CD, Carlson HC, Taylor WF, Weiland LP. Barium enemas of carcinoma of the colon: sensitivity of double- and single-contrast studies. *AJR* 1983; 140(6):1143-1149.
22. Rex DK, Rahmani EY, Haseman JH, Lemmel GT, Kaster S, Buckley JS. Relative sensitivity of colonoscopy and barium enema for detection of colorectal cancer in clinical practice. *Gastroenterology* 1997; 112(1):17-23.
23. Kalra L, Hamlyn AN. Comparative evaluation of investigations for colorectal carcinoma in symptomatic patients. *Postgrad Med J* 1988; 64(755):666-668.

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24. Irvine EJ, O'Connor J, Frost RA, et al. Prospective comparison of double contrast barium enema plus flexible sigmoidoscopy v colonoscopy in rectal bleeding: barium enema v colonoscopy in rectal bleeding. *Gut* 1988; 29(9):1188-1193.
25. Steine S, Stordahl A, Lunde OC, Loken K, Laerum E. Double-contrast barium enema versus colonoscopy in the diagnosis of neoplastic disorders: aspects of decision-making in general practice. *Fam Pract* 1993; 10(3):288-291.
26. Kewenter J, Brevinge H, Engaras B, Haglind E. The yield of flexible sigmoidoscopy and double-contrast barium enema in the diagnosis of neoplasms in the large bowel in patients with a positive Hemoccult test. *Endoscopy* 1995; 27(2):159-163.
27. Winawer SJ, Flehinger BJ, Schottenfeld D, Miller DG. Screening for colorectal cancer with fecal occult blood testing and sigmoidoscopy. *J Natl Cancer Inst* 1993; 85(16):1311-1318.
28. Rockey DC, Paulson E, Niedzwiecki D, et al. Analysis of air contrast barium enema, computed tomographic colonography, and colonoscopy: prospective comparison. *Lancet* 2005; 365(9456):305-311.
29. Williams CB, Macrae FA, Bartram CI. A prospective study of diagnostic methods in adenoma follow-up. *Endoscopy* 1982; 14(3):74-78.
30. Winawer SJ, Stewart ET, Zauber AG, et al. A comparison of colonoscopy and double-contrast barium enema for surveillance after polypectomy. National Polyp Study Work Group. *N Engl J Med* 2000; 342(24):1766-1772.
31. Kjaergard H, Nordkild P, Hennild V, Pedersen VM, Geerdsen J. Follow-up study after colorectal polypectomy. The predictive value of a negative double-contrast barium enema. *Scand J Gastroenterol* 1986; 21(3):353-356.
32. Saito Y, Slezak P, Rubio C. The diagnostic value of combining flexible sigmoidoscopy and double-contrast barium enema as a one-stage procedure. *Gastrointest Radiol* 1989; 14(4):357-359.
33. Glick S, Wagner JL, Johnson CD. Cost-effectiveness of double-contrast barium enema in screening for colorectal cancer. *AJR* 1998; 170(3):629-636.
34. Eddy DM, Nugent FW, Eddy JF, et al. Screening for colorectal cancer in a high-risk population. Results of a mathematical model. *Gastroenterology* 1987; 92(3):682-692.
35. Blakeborough A, Sheridan MB, Chapman AH. Complications of barium enema examinations: a survey of UK Consultant Radiologists 1992 to 1994. *Clin Radiol* 1997; 52(2):142-148.
36. Matsumoto T, Iida M, Kuroki F, et al. Dysplasia in ulcerative colitis: is radiography adequate for diagnosis? *Radiology* 1996; 199(1):85-90.
37. Ott DJ, Chen YM, Gelfand DW, Wu WC, Munitz HA. Single-contrast vs double-contrast barium enema in the detection of colonic polyps. *AJR* 1986; 146(5):993-996.
38. Rex DK, Vining D, Kopecky KK. An initial experience with screening for colon polyps using spiral CT with and without CT colonography (virtual colonoscopy). *Gastrointest Endosc* 1999; 50(3):309-313.
39. Fenlon HM, Nunes DP, Schroy PC, 3rd, Barish MA, Clarke PD, Ferrucci JT. A comparison of virtual and conventional colonoscopy for the detection of colorectal polyps. *N Engl J Med* 1999; 341(20):1496-1503.
40. Hara AK, Johnson CD, Reed JE, et al. Detection of colorectal polyps with CT colonography: initial assessment of sensitivity and specificity. *Radiology* 1997; 205(1):59-65.
41. Kay CL, Kulling D, Hawes RH, Young JW, Cotton PB. Virtual endoscopy--comparison with colonoscopy in the detection of space-occupying lesions of the colon. *Endoscopy* 2000; 32(3):226-232.
42. Laghi A, Iannaccone R, Carbone I, et al. Detection of colorectal lesions with virtual computed tomographic colonography. *Am J Surg* 2002; 183(2):124-131.
43. McFarland EG, Pilgram TK, Brink JA, et al. CT colonography: multiobserver diagnostic performance. *Radiology* 2002; 225(2):380-390.
44. Pineau BC, Paskett ED, Chen GJ, et al. Virtual colonoscopy using oral contrast compared with colonoscopy for the detection of patients with colorectal polyps. *Gastroenterology* 2003; 125(2):304-310.
45. Yee J, Akerkar GA, Hung RK, Steinauer-Gebauer AM, Wall SD, McQuaid KR. Colorectal neoplasia: performance characteristics of CT colonography for detection in 300 patients. *Radiology* 2001; 219(3):685-692.
46. Sosna J, Morrin MM, Kruskal JB, Lavin PT, Rosen MP, Raptopoulos V. CT colonography of colorectal polyps: a metaanalysis. *AJR* 2003; 181(6):1593-1598.
47. Ginnerup Pedersen B, Christiansen TE, Bjerregaard NC, Ljungmann K, Laurberg S. Colonoscopy and multidetector-array computed-tomographic colonography: detection rates and feasibility. *Endoscopy* 2003; 35(9):736-742.
48. Gluecker T, Dorta G, Keller W, Jornod P, Meuli R, Schnyder P. Performance of multidetector computed tomography colonography compared with conventional colonoscopy. *Gut* 2002; 51(2):207-211.
49. Iannaccone R, Laghi A, Catalano C, et al. Detection of colorectal lesions: lower-dose multi-detector row helical CT colonography compared with conventional colonoscopy. *Radiology* 2003; 229(3):775-781.
50. Macari M, Bini EJ, Xue X, et al. Colorectal neoplasms: prospective comparison of thin-section low-dose multi-detector row CT colonography and conventional colonoscopy for detection. *Radiology* 2002; 224(2):383-392.
51. Johnson CD, Harmsen WS, Wilson LA, et al. Prospective blinded evaluation of computed tomographic colonography for screen detection of colorectal polyps. *Gastroenterology* 2003; 125(2):311-319.
52. Macari M, Bini EJ, Jacobs SL, et al. Colorectal polyps and cancers in asymptomatic average-risk patients: evaluation with CT colonography. *Radiology* 2004; 230(3):629-636.
53. Pickhardt PJ, Choi JR, Hwang I, et al. Computed tomographic virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. *N Engl J Med* 2003; 349(23):2191-2200.
54. Cotton PB, Durkalski VL, Pineau BC, et al. Computed tomographic colonography (virtual colonoscopy): a multicenter comparison with standard colonography for detection of colorectal neoplasia. *JAMA* 2004; 291(14):1713-1719.
55. Pickhardt PJ, Taylor AJ, Kim DH, Reichelderfer M, Gopal DV, Pfau PR. Screening for Colorectal Neoplasia with CT Colonography: Initial Experience from the 1st Year of Coverage by Third-Party Payers. *Radiology* 2006; 241(2):417-425.
56. Macari M, Berman P, Dicker M, Milano A, Megibow AJ. Usefulness of CT colonography in patients with incomplete colonoscopy. *AJR* 1999; 173(3):561-564.
57. Morrin MM, Kruskal JB, Farrell RJ, Goldberg SN, McGee JB, Raptopoulos V. Endoluminal CT colonography after an incomplete endoscopic colonoscopy. *AJR* 1999; 172(4):913-918.
58. Neri E, Giusti P, Battolla L, et al. Colorectal cancer: role of CT colonography in preoperative evaluation after incomplete colonoscopy. *Radiology* 2002; 223(3):615-619.
59. Fenlon HM, McAneny DB, Nunes DP, Clarke PD, Ferrucci JT. Occlusive colon carcinoma: virtual colonoscopy in the preoperative evaluation of the proximal colon. *Radiology* 1999; 210(2):423-428.
60. Hartmann D, Bassler B, Schilling D, et al. Colorectal polyps: detection with dark-lumen MR colonography versus conventional colonoscopy. *Radiology* 2006; 238(1):143-149.
61. Pappalardo G, Poletini E, Frattaroli FM, et al. Magnetic resonance colonography versus conventional colonoscopy for the detection of colonic endoluminal lesions. *Gastroenterology* 2000; 119(2):300-304.
62. Limberg B. Diagnosis of large bowel tumours by colonic sonography. *Lancet* 1990; 335(8682):144-146.
63. Chui DW, Gooding GA, McQuaid KR, Griswold V, Grendell JH. Hydrocolonic ultrasonography in the detection of colonic polyps and tumors. *N Engl J Med* 1994; 331(25):1685-1688.

An ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those exams generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.