Quality in Colonoscopy and Impact on Colorectal Cancer Screening and Surveillance

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SUMMARY

Background: Despite declining rates of colorectal cancer (CRC) deaths in the United States, variation in the quality of colonoscopy is common and interval CRCs continue to occur, particularly in the right side of the colon. Quality indicators and performance targets have been developed to establish competence in performing colonoscopies and define areas for quality improvement. Adenoma detection rate (ADR), adequacy of bowel preparation, and adherence to recommended screening intervals have emerged as key quality indicators of screening quality and targets for improvement.

Aim: To describe current best practices in colonoscopy by reviewing the evolving evidence regarding ADR, adequacy of bowel preparation, and adherence to recommended screening intervals.

Methods: Articles from the PubMed database were reviewed for current and relevant data regarding screening colonoscopy, ADR, and bowel preparation.

Results: The best available evidence suggests that colonoscopy quality rather than quantity is the key to reducing the burden of interval CRCs. Consistent with current recommendations, endoscopists can feel confident that a normal colonoscopy can protect patients for 10 years, provided the bowel preparation was adequate and that the colonic mucosa was examined adequately by an endoscopist with an acceptable ADR. To that end, quality improvement initiatives should be undertaken for physicians failing to meet current benchmarks for ADR, adequate bowel cleansing, and adherence to screening intervals. Such initiatives should incorporate elements of knowledge (for both endoscopists and patients), technique, and adjunctive tools where appropriate.

INTRODUCTION

Over 4% of Americans will be diagnosed with colorectal cancer (CRC) at some point during their lifetime, and CRC remains the second most common cause of cancer death in the United States.[1] Over the past two decades, we have observed national declines in rates of CRC incidence deaths.[1] The declining trend has been attributed, at least in part, to early detection and resection of precancerous lesions associated with the increased use of CRC screening.[2–5]

Despite these improvements, interval CRCs continue to occur, particularly those in the right side of the colon.[2, 6] Further, screening colonoscopy is of little value if performed poorly, and variation in the quality of colonoscopy has been well-documented.[7–10] Recognizing the need to reduce this variation, the American Society for Gastrointestinal Endoscopy (ASGE) and the American College of Gastroenterology (ACG) have developed a list of quality indicators and performance targets to establish competence in performing colonoscopy and help define areas for quality improvement.[11] First published in 2006,[11] this set of indicators was revised in 2015 to incorporate newer evidence.[8] In the past five years, new evidence regarding best practices in colonoscopy has accumulated. With that in mind, we aim to review the evolving evidence with respect to three key quality indicators—adenoma detection rate (ADR), adequacy of bowel preparation, and adherence to recommended screening intervals—in an effort to improve the quality and optimize the benefits of screening colonoscopy.

UNDERSTANDING ADR

Originally proposed by the US Multi-Society Task Force (US MSTF) in 2002,[9] the ADR has emerged as the gold standard for measuring the quality of mucosal inspection during colonoscopy.[12, 13] Indeed, the US MSTF recommends that physicians performing screening measure the ADR, or the fraction of patients undergoing screening colonoscopy who had at least one adenoma detected.[14, 15] The proposed targets for the ADR is 25% overall, 30% in men, and 20% in women,[12] targets which fall below the mean ADRs in several screening colonoscopy studies.[15]

Impact of ADR on interval CRCs and death

The importance of the ADR as a predictor of cancer prevention by colonoscopy has been well established in the literature.[16, 17] Data from a large US integrated healthcare delivery organization was used to examine the association between ADR and the subsequent risks of CRC incidence and CRC-related deaths.[16] A very broad ADR, ranging from 7.4 to 52.5%, was documented across 314,872 colonoscopies performed by 136 gastroenterologists. Stratifying ADR across quintiles from lowest to highest demonstrated a strong inverse, linear relationship between the ADR and the risk of interval cancer over the 10-year follow-up period (**Figure 1**). This relationship was consistent across gender, cancers in the proximal and distal colon, and early and delayed interval cancers. Statistically, each 1% increase in ADR was associated with a 3% decrease in interval CRC risk (HR 0.97; 95% CI 0.96–0.98) and a 5% decrease in risk of death due to CRC. Importantly, there was no threshold effect beyond which increases in ADR were without benefit.

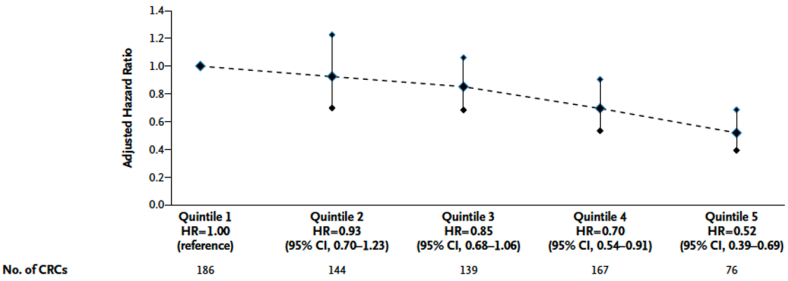

Figure 1. Hazard ratios for CRC according to ADR quintile.[16]

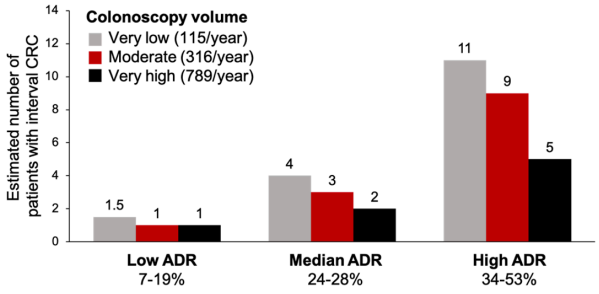

Figure 2. Estimated number of patients who will develop interval CRC in an endoscopist's career.[18]

It is important to not only consider an endoscopist's ADR but also their colonoscopy volume when predicting the rate of interval CRCs in their practice.[18] For example, a cohort screened by low-performing, high-volume endoscopists are the most at risk for interval CRC.[18] This was shown in an analysis of 93,562 outpatient colonoscopy examinations at 4 US clinical sites, whereby the expected interval CRC rate of 1 in every 3,174 colonoscopy examinations was modulated by both ADR and colonoscopy volume.[18] The model showed that interval CRCs varied considerably by ADR among those with high colonoscopy volumes (**Figure 2**), with low-performing, high-volume endoscopists showing the highest estimated number of interval CRCs over a 35-year career. Considering ADR and colonoscopy volume is an important target for quality improvement initiatives.

IMPROVING ADR IN 2020

A strategy that includes elements of knowledge, techniques, and tools is key to optimizing ADRs (**Table 1**). A fundamental prerequisite to detection is knowing the signature features of colon lesions, including hard-to-detect lesions.[19, 20] Improving the detection of subtle nonpolypoid and serrated lesions should be a focus for endoscopists, as these lesions are believed to play a key role in the development of "missed" or interval cancers, particularly those in the right side of the colon.[19–21]

The quality of the technical examination by the endoscopist is paramount in improving adenoma detection, even surpassing well-known predictors of adenomas such as older age and male gender.[22] Key behaviors that are associated with higher ADRs include time spent on inspection, looking behind folds, cleansing, and distention of the colon.[23]

Table 1. Key tips for improving ADRs

Knowledge/ mindset	1	Know the signature features of adenomas and serrated lesions
	2	Look for subtle lesions—think flat and depressed
Technique	3	Maintain a straight scope
	4	Clean the mucosa
	5	Look behind folds
	6	Expand and collapse the lumen
	7	Take adequate time, but be efficient
	8	Spend most time in the right colon, and examine twice
Adjunct tools	9	Know when adjustment is needed (e.g., lighting, cap, chromoendoscopy)
	10	Engage in quality assurance program

Tools for improving ADR

Adjunctive tools may facilitate lesion detection, particularly for low to moderate ADR providers. Robust evidence supports the ability of image-enhanced techniques (i.e., dye-based or electronic chromoendoscopy) to improve visualization in detecting and characterizing such lesions.[24, 25] Pooled results of seven prospective randomized trials demonstrated that the use of chromoendoscopy increased the likelihood of yielding significantly more people with at least one neoplastic lesion (OR, 1.53; 95% CI, 131–1.79).[25]

Endoscopic caps, which can improve visualization behind folds and turns, have also been found to improve ADR. In a meta-analysis of 4 studies involving 1,629 patents, the ADR among patients who underwent colonoscopy with a cap was 46.6% compared with 40.3% without a cap, for a pooled risk ratio of 1.14 (95% CI, 1.03–1.27; p = 0.01).[26] The cap significantly improved ADR in the detection of diminutive adenomas but provided no significant impact on the detection of adenomas in the right side of the colon, those 6 mm or larger, or on the mean number of advanced adenomas detected per patient. More recently, a multicenter RCT in 1,772 patients demonstrated that the use of Endocuff Vision increased ADR from 36.2% to 40.9% (p = 0.02) in those undergoing standard colonoscopy, an increase driven by improvement in patients who were fecal occult blood positive.[27] A meta-analysis of 12 RCTs involving 8,376 patients demonstrated significant improvement in ADR in patients who underwent Endocuff-assisted colonoscopy compared with standard colonoscopy (41.3% vs 34.2%; RR,1.20; 95% CI, 1.06–1.3; p = 0.003).[28] This difference was particularly pronounced for endoscopists with low-to-moderate ADRs (< 35%).

Growing evidence supports the benefit of water-aided colonoscopy techniques (water immersion and water exchange) in minimizing insertion pain and optimizing ADR.[29–31] In particular, two recent meta-analyses, each involving 17 RCTs, found water exchange to improve overall ADR compared with water immersion[29] and air and/or carbon dioxide insufflation.[29, 30] The highest ADRs with water exchange were observed in the right side of the colon, in CRC screening cases, and in patients taking a split-dose preparation.[29]

Training and quality improvement interventions

Although reported outcomes of educational interventions to improve ADR have varied,[32] increasing evidence indicates that focused training and quality improvement interventions can improve adenoma detection. In an earlier study, the impact of an educational intervention designed to improve both detection and recognition of polyps with neoplastic potential was assessed using data from 2,400 colonoscopies performed by 15 staff endoscopists at a single institution.[23] The ADR of endoscopists who were randomized to receive the training increased from a baseline of 36% to 47% after training, whereas the ADR of the untrained group remained constant at 35%. The odds ratio for the increase in ADR after training was 1.73 (95% CI, 1.24–2.41; p = 0.0013). Increased ADR associated with the training was observed across all procedure indications, lesion sizes, and lesion shapes.

More recently, a large single-blind, parallel-group study compared the impact of a hands-on training course for colonoscopists at 40 Polish screening centers with that of a simple audit and feedback program.[33] Analysis of data from 24,582 colonoscopies performed by 38 endoscopists demonstrated a larger improvement in ADR among those who participated in the training compared with those who did not in both the early post-training phase (within six months) (OR, 1.61; 95% CI, 1.29–2.01; $p < 0.001$) and the late post-training phase (6 to 18 months) (OR, 1.35; 95% CI, 1.10–1.66; $p = 0.004$). Similarly, a cross-over study conducted across 20 medical centers and 86 endoscopists demonstrated that an online interactive training module combined with feedback on ADRs resulted in a mean improvement in endoscopist ADRs from 31.5% to 37.4% ($p < 0.01$) during the two years after the intervention (**Figure 3**).[34] The 30-minute training module was created with novel behavioral change techniques and focused on poly identification, clearing/washing techniques, and colonoscopy quality.

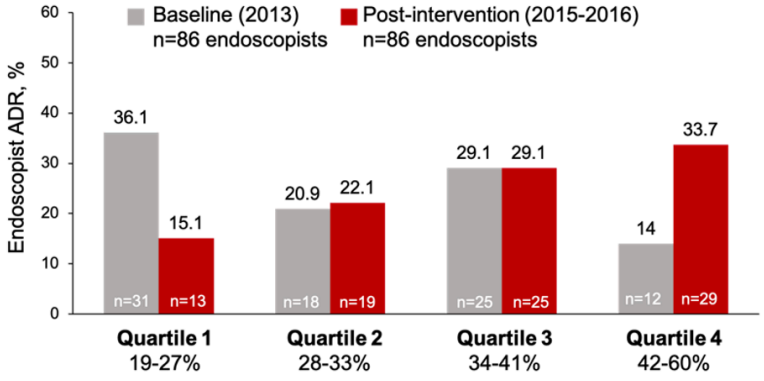

Figure 3. Endoscopist ADRs before and after educational intervention.[34]

Given the subtle appearance of nonpolypoid lesions and their potential role in the development of interval CRC, the impact of training endoscopists to diagnose these lesions is an area of growing interest.[35, 36] To that end, a retrospective nested case control study compared the ADR of colonoscopists who were trained in the features and diagnosis of nonpolyoid lesions with those without this training.[35] Over the 18-month study period, 267 patients underwent screening colonoscopy by colonoscopists trained in the detection of nonpolypoid neoplasias, while 195 were screened by colonoscopists with conventional training. Compared with the conventionally trained group, trained colonoscopists had a higher ADR (0.76 vs 0.54 adenomas per patient, $p < 0.001$), removed a higher proportion of neoplasia (77 vs 35%, $p < 0.001$), and diagnosed nonpolypoid colorectal neoplasias more frequently (OR 2.98, 95% CI 1.46–6.08). Importantly, the ability to detect nonpolypoid adenomas appears to be associated with a considerable learning curve.[36]

The impact of improving ADR

Recent data indicate that improving individual endoscopists' ADRs translates into significantly lower risks of incident and fatal CRC after screening colonoscopy.[17] In a prospective cohort study, data were collected from 146,860 colonoscopies performed by 294 endoscopists involved in the Polish National Colorectal Cancer Screening Program.[17] Annual feedback and quality benchmark indicators (ADR, cecal intubation rate) were used to improve colonoscopy performance. Over the period of 2004 to 2008, the proportion of endoscopists in the lowest ADR category (≤ 11.21%) decreased from 30.7% to 10.2%, while those in the highest ADR category increased from 8.1% to 30.1% (> 24.56%). Over the median follow-up of 5.8 years, reaching or maintaining an annual ADR ≥ 24.6% was associated with a profound and statistically significant reduction in the risk of interval CRC (adjusted HR for interval CRC, 0.27; 95% CI, 0.12–0.63; $p = 0.003$ and 0.18; 95% CI, 0.06–0.56; $p = 0.003$, respectively) (**Figure 4**). In other words, compared with no improvement reaching an ADR ≥ 24.6% translated into a reduction in interval CRC rates from 25.3 to 7.1 cases per 100,000 patient-years of follow-up.

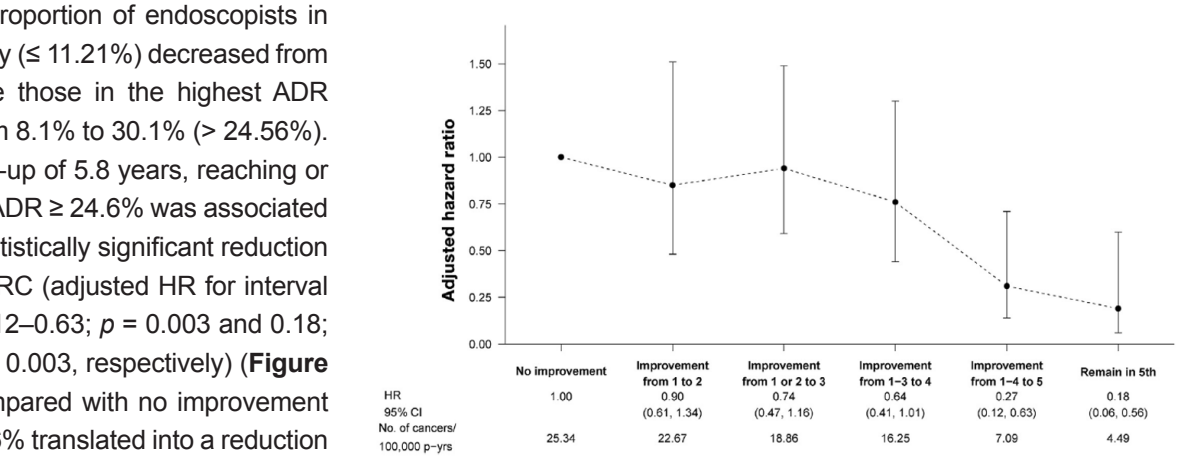

Figure 4. Adjusted hazard rates for interval CRC according to ADR improvement category.[17] Vertical lines indicate 95% CIs.

Consistent with these findings, data from a large multicenter healthcare delivery organization demonstrated that higher ADRs from an educational intervention were associated with a significant and substantial reduction in the risk of post-colonoscopy CRC.[34] During the two years after completing an interactive online training module and receiving ADR feedback, the adjusted risk of post-colonoscopy CRC was 45% lower among patients of endoscopists who had post-intervention ADRs at or above the median level of 34% (adjusted HR ,0.55; 95% CI, 0.31–0.98).

OPTIMIZING BOWEL PREPARATION

The link between the adequacy of bowel cleansing and successful colonoscopy is well recognized, and inadequate bowel preparation is a major contributor to failed colonoscopy.[37–39] Inadequate bowel preparation is associated with profound consequences, ranging from increased costs due to rescheduling and wasted resources to missed CRCs.[38, 40–42] Indeed, various studies have reported adenoma miss rates of up to 48% due to inadequate bowel preparation.[43–45] Unfortunately, bowel preparation is acknowledged by patients as the most difficult aspect of colonoscopy,[46] and inadequate bowel preparation continues to occur in up to 40% of all colonoscopies.[37, 38]

Defining an adequate bowel preparation

Current guidelines consider a colonoscopy examination to be adequate if it allows detection of polyps > 5 mm in size.[8, 38] Examinations that are inadequate under this definition should be repeated, generally with a more aggressive preparation regimen, within one year or less when advanced neoplasia is detected.[8, 38] Despite these recommendations, there is substantial variability in endoscopists' interpretation of what constitutes an adequate bowel preparation and its impact on future screening colonoscopy.[47, 48] This inconsistency is heightened by the availability of different scales for rating the adequacy of bowel cleansing. While the Aronchick Scale and Boston Bowel Preparation Scale (BBPS) are among the most widely used validated scales, current guidelines do not specify a preferred bowel preparation scale.[12, 48]

Given the significant consequences of inadequate bowel preparation, the quality of bowel cleansing is both a required element of the colonoscopy report and an important quality measure.[12, 38, 39, 49] The US MSTF and the ASGE/ACG recommend a target minimum of 85% for adequate bowel cleansing of all outpatient examinations.[8, 38] Improvement initiatives should be undertaken for endoscopists failing to meet this target.[38] The benchmarks for adequate bowel preparation recommended by the European Society of Gastrointestinal Endoscopy (ESGE) are slightly higher, with a proposed minimum of 90% and a target standard of ≥ 95%.[39]

Predictors of inadequate bowel preparation

A large body of evidence has highlighted a number of medical and non-medical factors that are predictive of inadequate bowel preparation (**Table 2**). In a meta-analysis of 67 studies involving 75,818 patients, advanced age and male sex were the key demographic factors that predicted inadequate preparation.[50] Low education was a significant predictor,[50] a finding consistent with studies reporting a negative impact of various socioeconomic factors on bowel cleansing.[37, 51] Factors including, insurance type, low health literacy, and low patient activation increase the risk of patients not following instructions.[40] Other factors that have emerged as significant predictors of inadequate bowel preparation include comorbidities (diabetes, constipation, obesity, stroke), the use of opioids or tricyclic antidepressants, and prior colonoscopies due to inadequate bowel preparation.[37, 50, 51] Patients with these risk factors represent an important target for intensive educational interventions, such as educational brochures, reminders, and patient navigators.[37]

Choosing a bowel preparation regimen

The choice of bowel preparation regimens is based on efficacy, tolerability, and safety.[37, 38] Although efficacy is the primary clinical goal, it must be balanced with tolerability, as patients may not fully ingest poorly tolerated regimens and may not achieve an adequate cleansing.[37, 38] Poorly tolerated regimens also decrease patients' willingness to repeat procedures, in turn increasing the risk of CRC.[37, 52]

Table 2. Predictors of inadequate bowel preparation[37, 50, 51]

Medical/demographic predictors	Predictors of not following instructions
Male sex	Non-English speaking
Advanced age (> 65 years)	English not first language
Previous failed bowel preparation	Medicaid insurance
Chronic constipation	Lower educational level
Diabetes	Low health literacy
Stroke	Low patient activation
Dementia	Later procedure start time
Cirrhosis	
Parkinson's disease	
Use of constipating medications (opioids, tricyclic antidepressants)	
Obesity	

Table 3. FDA-approved bowel preparation agents in the United States

	Agent (Brand name[s])	Formulation	Volume	Key Warnings
High-volume	**PEG-ELS**			
	PEG-ELS (GoLYTELY®, Colyte®)[91, 92]	PEG-3350, sodium sulfate, sodium bicarbonate, sodium chloride, potassium chloride	4 L	Fluid/electrolyte abnormalities, seizures, renal impairment, risk of aspiration or GI osbtruction/perforation
	SF-PEG-ELS (NuLYTELY®, TriLyte®)[93, 94]	PEG-335-, sodium bicarbonate, sodium chloride, potassium chloride	4 L	As above
Low-volume	Low volume PEG-ELS with ascorbic acid (MOVIPREP®)[95]	PEG-3350, sodium sulfate, sodium chloride, potassium chloride, ascorbic acid	2 L + 16 oz of clear liquids with each dose (5 mL)	As above, plus caution in G6PD deficiency
	Low volume PEG-3350 (PLENVU®)[96]	PEG-3350, sodium sulfate anhydrous, sodium ascorbate, ascorbic acid	1 L + 16 oz of clear liquids with each dose (500 mL)	As above, plus caution in G6PD deficiency
	Hyperosmotic preparations			
	Oral sodium sulfate (Suprep®)[60]	Sodium sulfate, potassium sulfate, magnesium sulfate	12 oz; 2.5 L water	Fluid/electrolyte abnormalities, seizures, renal impairment, risk of aspiration or GI obstruction/perforation
	Sodium picosulfate, magnesium oxide, anhydrous citric acid (Prepopik®, Clenpiq™)[61, 97]	Sodium picosulfate, magnesium oxide, anhydrous citric acid	10 oz; 2 L water	As above, plus mucosal ulcerations, when interpreting colonoscopy findings in patients with known or suspected IBD
	Sodium phosphate tablets (OsmoPrep®)[98]	Monobasic and dibasic sodium phosphate	32 tablets, 2 L water	As above. Boxed warning regarding risk of acute phosphate nephropathy, caution in patients with IBD

GI, gastrointestinal; IBD, inflammatory bowel disease; G6PD, glucose-6-phosphate dehydrogenase deficiency; PEG-ELS, polyethylene glycol.

Bowel preparations can be broadly viewed as polyethylene glycol-electrolyte lavage solutions (PEG-ELS) or hyperosmotic preparations that contain poorly absorbed multivalent cations or anions with osmotic effects (**Table 3**).[38, 51] The efficacy of high-volume PEG-ELS is well-established,[53–55] but poor palatability and tolerability can influence compliance with these regimens.[54] Although still considered the gold standard of efficacy,[37, 51] a meta-analysis of 21 trials failed to demonstrate a significant increase in bowel cleanliness with 4-L PEG-ELS compared with low-volume PEG-ELS (OR,1.03; 95% CI, 0.80–1.32).[38] Among the various low-volume PEG-ELS, comparative, controlled trials have not demonstrated significant differences in the overall bowel and right-sided colon cleansing efficacy of these preparations.[56, 57] Comparable efficacy has also been shown between a low-volume oral sodium sulfate and PEG-ELS with ascorbic acid[58] as well as a preparation of sodium picosulfate and magnesium oxide.[59]

Polyethylene glycol-based bowel preparations are generally safe and well tolerated. The most common adverse effects of nausea, abdominal pain, and bloating may be reduced with low-volume preparations.[51] Because they are iso-osmotic, PEG-ELS are often preferred in patients with conditions (e.g., renal insufficiency, congestive heart failure, advanced liver disease) that would render them less likely to tolerate fluid shifts.[37, 38]

Potential adverse effects of sodium phosphate preparations include fluid shifts, hyperphosphatemia, electrolyte abnormalities, seizures, mucosal damage, and acute phosphate nephropathy.[51] Although adverse renal effects from these preparations are rare, their use is best reserved for otherwise healthy patients. The most common adverse effects associated with sodium sulfate include abdominal fullness or cramping, nausea, and vomiting,[60] but this preparation does not cause significant electrolyte or fluid shifts in patients with cardiac, renal, or liver disease.[51] The hyperosmotic preparation of sodium picosulfate and magnesium can cause nausea and vomiting, and has been noted to precipitate severe hyponatremia in older adults.[51, 61]

Timing of bowel preparation

Bowel preparation regimens have evolved from the traditional previous evening regimen to splitting the dose between the night before and the day of the colonoscopy (split dosing) or giving it on the day of the procedure (same-day dosing).[8, 38, 62] Importantly, all bowel preparations can be administered as split-dose or same-day regimens.[37] A robust body of evidence has demonstrated that split-dosing improves bowel preparation quality compared with day-before dosing. In a meta-analysis of 32 RCTs involving 8,199 patients, split-dose regimens achieved superior bowel cleanliness to day-before regimens, regardless of product, dosage, or addition of adjuvant (OR, 2.51;95% CI, 1.86–3.39).[55] Further, pooled data indicate that split-dose PEG-ELS significantly increases patient willingness to repeat the same preparation[53, 55] while decreasing nausea[53] as well as the number of discontinuations.[53]

Based on these data, all current guidelines endorse split-dose regimens, with half the dose of the bowel preparation given on the day of the examination.[12, 14, 38, 39] The second dose should begin four to five hours before the scheduled colonoscopy and should be finished at least two hours before the procedure.[12] For afternoon colonoscopies, the entire dose can be ingested on the day of the examination.[12]

Multiple studies also support the efficacy of same-day bowel preparation regimens as an alternative to split-dosing.[63, 64] A meta-analysis of 15 trials found no significant differences with respect to quality of bowel preparation, adenoma detection, tolerability, or willingness to repeat the regimen.[63] Although adverse effects were similar, patients who used same-day regimens reported less bloating and a trend toward less interference with sleep. Similar results were found with a more recent meta-analysis of 14 trials, with comparable outcomes between split-dose and same-day regimens with respect to bowel cleanliness, cecal intubation rate, and ADR.[64] As in the previous meta-analysis, same-day regimens were associated with better sleep than split-dose regimens.

Other considerations

In contrast to the traditional diet recommendation of clear liquids, increasing evidence supports the use of a liberalized diet the day before colonoscopy.[38] A meta-analysis of nine studies involving 1,686 patients demonstrated significantly higher odds of tolerability and willingness to repeat the preparation among patients who consumed a low residue diet compared with a clear liquid diet before colonoscopy with no differences in adequate bowel preparation or adverse effects.[65] Consistent results were reported more recently in a meta-analysis of 12 studies in which no significant differences in bowel preparation quality or adenoma detection were reported among patients who received low-residue or regular diets compared with clear liquids.[66] However, tolerability and willingness to repeat favored patients who consumed liberalized diets. Given these data, current US MSTF guidelines recommend either low-residue or full liquid diets until the evening on the day before colonoscopy.[38]

The use of adjunctive agents for bowel cleansing before colonoscopy is not recommended by the US MSTF due to a lack of data demonstrating improved efficacy of cleansing with their use.[38] These agents include flavored electrolyte solutions (e.g., Gatorade), simethicone, prokinetics, spasmolytics, bisacodyl, senna, and probiotics. The best studied of these agents is simethicone, which has been used to improve visualization by eliminating colonic bubbles.[67] Although an earlier meta-analysis of seven RCTs failed to demonstrate a significant effect of simethicone on colon cleanliness or diagnostic yield,[68] subsequent RCTs have found that higher doses of simethicone decreases the amount of bubbles,[67, 69–71] improves bowel cleanliness,[69–71] and improves ADR[69, 70] compared with regimens without simethicone. Accordingly, the ESGE recommends adding simethicone to bowel preparations.[72]

Patient education

Because patient noncompliance is a strong predictor of suboptimal bowel preparation with split-dose regimens,[73] patient education interventions aimed at increasing patient understanding and compliance have the potential to improve the quality of bowel preparation. To that end, multiple different patient education interventions have been shown to improve the quality of bowel preparation.[74–76] A meta-analysis of eight RCTs (N = 3,795) found that patients who received enhanced instructions had significantly better quality of bowel preparation than those receiving regular instructions (OR, 2.35; 95% CI, 1.65–3.35; $p < 0.001$).[75] This benefit was consistent across patients receiving different types of regimens, administrations, and diet restrictions. Recognizing the importance of patient education to bowel preparation quality, the US MSTF recommends that both oral and written patient education instructions be provided to patients before colonoscopy.[38] Further, given the association of socioeconomic factors with the risk of suboptimal bowel preparation,[40, 50] it is important that educational tools be provided across a range of health literacy and education levels.[38]

REAFFIRMING THE 10-YEAR INTERVAL AFTER NORMAL SCREENING COLONOSCOPY

The 2020 US MSTF guidelines recommend colonoscopic screening at 10-year intervals in the average-risk population, with shorter intervals recommended for those with adenomas (**Figure 5**).[49] The quality benchmark for this recommendation is ≥ 90%,[8] allowing endoscopists some flexibility to use their clinical judgment in a minority of patients.[21] The endoscopist is expect to document histology and his/her written recommendation to the patient for repeat colonoscopy in the colonoscopy report and in a follow-up letter to the patient if biopsies or polypectomy are performed.[8]

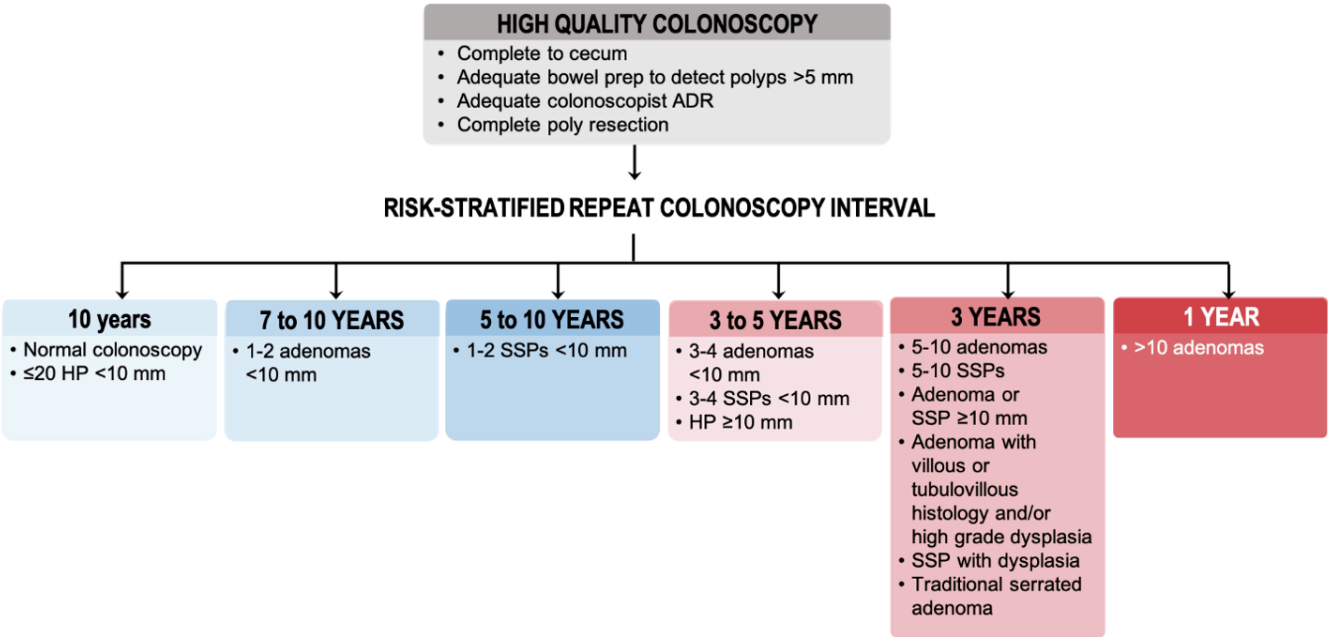

Figure 5. 2020 US MSTF recommendations for follow-up in average-risk adults after colonoscopy and polypectomy.[49]
SP, sessile serrated polyp/sessile serrated adenoma/sessile serrated lesion.

Despite these recommendations, patients are commonly instructed to have repeat screening colonoscopies after five years or less after normal colonoscopies.[77–79] In a study involving 24,071 Medicare enrollees with negative screening colonoscopies from 2001 through 2003, nearly one in four (23.5%) of all patients had repeat colonoscopy in less than seven years without any indication for repeat colonoscopy.[77] Similarly, a retrospective, observational study from a national sample of 50- to 64-year-old patients (N = 1,455) in the Veterans Affairs healthcare system found that recommendations for repeat colonoscopy were consistent with screening guidelines in only 64% of patients.[79] Approximately 19% of patients with no polyps and 32% of those with hyperplastic polyps were instructed to have a repeat colonoscopy within five years.

Most recently, the adherence to 10-year intervals after a normal screening colonoscopy was assessed as part of the Michigan CRC Screening Quality Improvement Project.[80] Data from colonoscopies performed in 2017 in 1,694 patients of average-risk aged 50 to 75 years were used to characterize adherence, which was defined as repeat colonoscopy in 10 years or a documented decision to stop further screening colonoscopy due to the patient's age or comorbid medical condition. Recommending repeat colonoscopy in < 1 year due to inadequate bowel preparation was also considered guideline adherent. Adherence among academic gastroenterologists was significantly better than that of private practice gastroenterologists and academic general surgeons (90% vs 39% and 10%, respectively; $p = 0.04$).

This overuse of screening colonoscopy is likely driven by a number of factors. Some endoscopists simply disagree with current guidelines, believing that 10 years is too long to wait for repeat colonoscopy.[21, 81] In one survey of gastroenterologists preparing

for recertification examination, up to 76% of the respondents reported that they disagreed with the recommended 10-year screening interval and chose to perform repeat screening colonoscopy sooner than recommended.[81] The quality of bowel preparation also strongly influences adherence to guideline recommendations.[82–84] A retrospective review of 1,387 average-risk individuals aged 50 years and older with a normal screening colonoscopy found that patients with fair bowel preparation quality based on the Aronchick scale were significantly more likely to be told to return in fewer than 10 years (OR, 18.0; 95 CI, 12.0–28.0) than those with excellent or good preparation.[84] Data from the Michigan CRC Screening Quality Improvement Project reported similar findings, with adherence to guideline-consistent intervals significantly better with good/excellent bowel preparations compared to those with poor, fair, or no documentation of preparation quality ($p < 0.05$).[80]

Ultimately, endoscopists should recognize that overuse of screening colonoscopy by using three to five year intervals is unlikely to prevent an interval CRC.[21, 85, 86] This is because most interval CRC occurs *within the first three years* after a normal screening colonoscopy. The best current support for this principle is derived from analysis of data from the Veterans Affairs Cooperative Study 380 (VA CSP 380).[86] In this study, 10-year follow-up data were obtained from average-risk veterans who underwent screening colonoscopy from 1994 through 1997.[86] The cumulative incidence of advanced adenoma and CRC among the 932 subjects with normal screening colonoscopy at baseline who underwent a second screening within 10 years was 4.1% (95 CI, 2.7–5.4%) and 0.8% (95% CI, 0.2–2.4%), respectively. Most importantly, the incidence rates of both advanced adenoma and CRC were highest within the first three years after baseline colonoscopy across all risk groups (**Figure 6**). Further, among all subjects without CRC at baseline, the incidence rate of CRC was close to zero after the first three years of surveillance. This is because most interval CRC arise on the the right side of the colon because large flat adenomas, sessile serrated adenomas/polyps, or traditional serrated adenomas were missed, possibly in combination with suboptimal bowel preparation.[2, 20, 21, 87–89] Accordingly, repeating screening colonoscopy at three to five year intervals will not lead to identification and removal of most of these lesions before they advance to CRC.

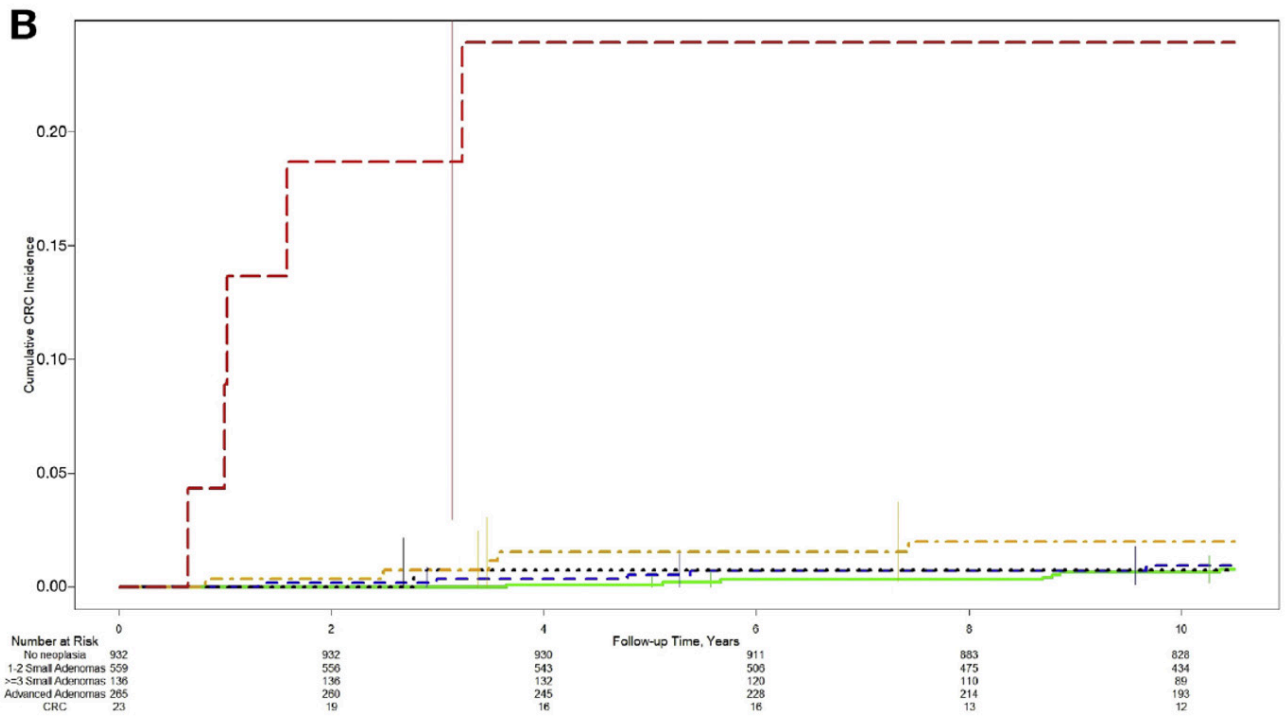

Figure 6. Cumulative CRC incidence curves with 95% CIs over 10 years of surveillance by baseline screening outcome with number at risk at two-year time intervals along the x-axis.[99]
Participants were censored after the first surveillance cancer, death, or date of last visit recorded in the VA EMR. Each line represents the baseline risk group after the screening colonoscopy. Error bars indicated 95% CIs at the given time point. Compared with baseline no neoplasia, *p*-values for log-rank pairwise comparisons were $p < 0.001$ for baseline CRC, advanced adenomas, and ≥ 3 small adenomas, and $p = 0.1$ for one to two small baseline adenomas.

Given these findings, the 2020 US MSTF guidelines emphasize that colonoscopies need to be complete to the cecum with an adequate bowel preparation by an endoscopist *with an adequate ADR* for the recommended intervals to work well.[49] Thus, it is crucial to identify endoscopists with inadequate ADRs and intervene so that they can improve their ADRs. If the bowel preparation is not adequate to identify polyps > 5 mm or the cecum is not reached, a repeat colonoscopy should be done within one year. Fortunately, however, the frequency of interval CRC after colonoscopy appears to be decreasing,[86, 90] with considerable improvement noted in those occurring in the right side of the colon.[6]

The best available evidence suggests that endoscopists can feel confident that a normal colonoscopy can protect patients for 10 years, provided the bowel preparation was adequate and that the colonic mucosa was examined adequately by an endoscopist with an acceptable ADR. It is especially important to carefully examine the right side of the colon for large flat SSA/Ps and TSAs and ensure adequate visualization with copious washing and suctioning of residual stool if needed.[21]

Future directions

Adenoma detection rate, cecal intubation rate, and adherence to 10-year intervals after a normal screening colonoscopy in an average-risk patient are considered *priority* quality indicators in the 2020 Multi-Society Position Statement on Quality Indicators in Colonoscopy.[49] Although ADR and cecal intubation rate are routinely calculated in programs that monitor quality indicators, adherence to 10-year intervals after a normal screening colonoscopy is not based on review of the literature. Therefore, improvement in this quality indicator is fairly straightforward. This must become an outcome that is routinely measured in quality assurance programs, allowing identification of poor performers, education regarding the low value of repeating screening colonoscopies at three to five year intervals, and monitoring improvement as part of ongoing quality assurance initiatives.

CONCLUSIONS

Despite declining national rates of colorectal cancer (CRC) deaths, variation in the quality of colonoscopy is common and interval CRCs continue to occur, particularly in the right side of the colon. Recognizing this variation, quality indicators and performance targets have been developed to establish competence in performing colonoscopies and define areas for quality improvement. Given its significant inverse association with interval cancer, ADR is widely regarded as the gold standard for measuring the quality of mucosal inspection during colonoscopy. However, emerging data indicate the contribution of both ADR and colonoscopy volume in predicting the rate of interval CRCs in clinical practice. Strategies for optimizing ADRs should emphasize knowledge of the signature features of colon lesions and methods for improving technique. Adjunctive tools (e.g., endoscopic caps, water-assisted techniques) can also facilitate lesion detection, particularly for low to moderate ADR providers.

Recognizing the contribution of inadequate bowel preparation to failed colonoscopy, the quality of bowel cleansing is both a required element of the colonoscopy report and an important quality measure. Key improvement initiatives should be undertaken for endoscopists failing to meet current benchmarks for adequate bowel preparation, including education regarding the benefits of split-dose and same-day regimens and evidence regarding liberalized diets before colonoscopy. Patient education interventions can also improve the quality of bowel preparation, particularly among those at risk for inadequate preparation (e.g., advanced age, comorbidities, low education level, and non-English speaking).

Despite current recommendations for colonoscopic screening at 10-year intervals in average-risk individuals, patients are commonly instructed to have repeat screening colonoscopies within three to five years of normal colonoscopies. Because most interval CRC occurs within the first three years after a normal screening colonoscopy, however, overuse of screening colonoscopy is unlikely to prevent interval CRCs. Current evidence demonstrates that a normal colonoscopy can protect patients for 10 years, provided the bowel preparation was adequate and that the colonic mucosa was examined adequately by an endoscopist with an acceptable ADR. In light of these caveats, careful examination of the right side of the colon for large flat SSA/Ps and TSAs is of paramount importance. Taken collectively, the best available evidence suggests that colonoscopy quality rather than quantity is the key to reducing the burden of interval CRCs.

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