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Authors
May, Folasade P
Shaukat, Aasma

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State of the Science on Quality Indicators for Colonoscopy and How to Achieve Them

Folasade P. May, MD, PhD[1,2] and Aasma Shaukat, MD, MPH[3,4]

Colonoscopy is a safe and effective tool, but operator dependent. Room for improvement in the quality of colonoscopy is the impetus for the development and measurement of colonoscopy quality indicators and the focus of many efforts to improve colonoscopy quality indicator prevention and control in provider practices and health systems. We present the preprocedural, intraprocedural, and postprocedural quality indicators and benchmarks for colonoscopy. Every provider and practice must make a commitment to performing high-quality colonoscopy and implement and monitor quality metrics. There are a variety of tools available to assist in improving quality indicators that range from distal attachment devices to education and feedback. Although technology can help, it is not a substitute for proper technique. The commitment also requires provider feedback through audits and report cards. The impact of these efforts on patient outcomes is an important area of further research.

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INTRODUCTION

Colonoscopy is one of the most common medical procedures, with over 19 million performed annually in the United States (1). Currently, the large majority of colorectal cancer (CRC) screening in the United States is performed with colonoscopy (2), which is estimated to reduce CRC incidence and mortality by 40% and 50%, respectively (3,4). Despite common use and general acceptance as the gold standard for CRC screening, colonoscopy is imperfect and has variable quality in the United States (5). Adenoma miss rates are between 9% and 26% in tandem colonoscopy studies (6). In addition, 2.1%–7.7% of CRCs diagnosed are interval cancers that develop after screening colonoscopy but before subsequent surveillance is indicated (7–11). Attention to quality is paramount for the millions of colonoscopies performed each year and has the potential to increase value of care by reducing complications, minimizing interval CRC, and increasing patient satisfaction (5,12). The importance of maximizing colonoscopy quality was highlighted by the Centers for Medicare and Medicaid Services Physician Quality Reporting System in 2007, which has since been transitioned into a newer pay for performance program by the Centers for Medicare and Medicaid Services called the Merit-based Incentive Payment System. The Merit-based Incentive Payment System is designed to tie payments to quality and cost-efficient care to drive improvements in care and health outcomes. Hence, quality in colonoscopy is not just a lofty goal for safe and effective outcomes, but tied to payments. However, how to best measure and apply these colonoscopy quality indicators (CQIs) in day-to-day clinical practice is a challenge for gastroenterologists in both academic and community settings. We aim to provide some practical advice for gastroenterologists and clinical practices that wish to optimize the use of CQIs to improve colonoscopy performance and CRC outcomes.

Quality indicators in colonoscopy

The primary goal of establishing CQIs is to reduce interval CRCs and adverse events during colonoscopy. In 2015, the American Society for Gastrointestinal Endoscopy (ASGE) and the American College of Gastroenterology (ACG) published an updated list of CQIs for colonoscopy (Table 1) (13). The list includes both outcome and process measures divided into 3 time periods: preprocedure, intraprocedure, and postprocedure. The Task Force also provides performance target goals for each CQI.

Preprocedural CQIs

The 4 preprocedural CQIs (Table 1) emphasize documentation of the indication for colonoscopy and informed consent, and adherence to appropriate surveillance intervals. These CQIs aim to reduce inappropriate procedures, increase the yield of clinically relevant diagnoses, and maximize patient safety (13). In most clinical settings, these process measures are documented in the preprocedure note or the electronic health record (EHR). However, directing providers to include this information in the endoscopy report can facilitate routine collection of these data and the determination of frequencies at which these CQIs are achieved. In addition to increasing provider awareness and education about these CQIs, endoscopic reporting tools that provide templates in which endoscopists (or support staff) can enter these fields can further facilitate capture of this information through data query.

[1]Vatche and Tamar Manoukian Division of Digestive Diseases, Department of Medicine, David Geffen School of Medicine at UCLA, Los Angeles, California, USA; [2]Department of Medicine and VA HSR&D Center for the Study of Healthcare Innovation, Implementation and Policy (CSHIIP), VA Greater Los Angeles Healthcare System, Los Angeles, California, USA; [3]Department of Medicine, Section of Gastroenterology Minneapolis VA Medical Center, Minneapolis, Minnesota, USA; [4]Department of Medicine, University of Minnesota, Minneapolis, Minnesota, USA. **Correspondence:** Aasma Shaukat, MD, MPH. E-mail: shaukat@umn.edu.
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Table 1. Quality indicators for colonoscopy

Quality indicator	Performance target
Preprocedure	
Appropriate indication documented	>80%
Informed consent obtained	>98%
Appropriate postpolypectomy surveillance interval	≥90%
Appropriate ulcerative colitis and Crohn's surveillance interval	≥90%
Intraprocedure	
Documentation of bowel preparation quality	>98%
Adequate bowel preparation to perform adequate examination	≥85%
Documentation of cecal intubation (notation and photo documentation)	≥90% all ≥95% screening
ADR	≥30% males ≥20% females ≥25% combined
Documentation of WT	>98%
Average WT for negative examinations	≥6 min
Biopsies for indication of chronic diarrhea	>98%
Tissue sampling for ulcerative colitis and Crohn's	>98%
Attempted endoscopic removal of pedunculated polys and sessile polyps before surgical removal	>98%
Postprocedure	
Monitor perforation incidence (all examinations, screening examinations)	< 1:500 all < 1:1,000 screening
Monitor postpolypectomy bleed incidence	< 1%
Monitor postpolypectomy bleed requiring surgery (of those with a bleeding complication)	≥10%
Surveillance interval recommendation provided to patient	≥90%

ACG, American College of Gastroenterology; ADR, adenoma detection rate; ASGE, American Society for Gastrointestinal Endoscopy; WT, withdrawal time. Adapted from the ASGE/ACG Task Force on Quality in Endoscopy, 2015, with permission from the American College of Gastroenterology (ref. [13]).

Intraprocedural CQIs

The primary goal of most colonoscopic procedures is to detect neoplastic and preneoplastic lesions. The ASGE/ACG Task Force designates 9 intraprocedural CQIs to encourage detailed mucosal evaluation during colonoscopy. Of these, adenoma detection rate (ADR), bowel preparation quality, withdrawal time (WT), and cecal intubation rate are of paramount importance and have been linked to interval (postcolonoscopy) CRC. These indicators are discussed in the sections below.

Adenoma detection rate: The ADR, which is the proportion of average-risk patients undergoing screening colonoscopy in whom an adenoma or CRC is found, is regarded as a robust measure of colonoscopy performance quality that correlates with subsequent CRC risk (14–16). The current benchmarks are 30% for men and 20% for women 50 years and older, for a blended rate of 25% (17). It is important to note that ADR measurement excludes sessile serrated lesions, which, although important, have larger inconsistencies in detection rate because of the provider and pathologist reporting variability. Therefore, sessile serrated lesions should not be considered in calculating the ADR at this time.

ADR has been shown to be significantly associated with the risk of interval cancers. In a provocative landmark study by Kaminski et al. (16) in which 45,026 patients involved in a Polish nationwide CRC screening program were followed over time, and interval cancers were determined at the scheduled time of surveillance colonoscopy, endoscopists with ADRs less than 20% (categorized as less than 11.0%, 11.0%–14.9%, 15.0%–19.9%, and 20.0% or more) had a more than 10-fold higher rate of interval CRCs than those with higher ADRs. Another more recent study that also supports the relationship between ADR and interval cancer comes from Corley and colleagues. Physician ADR (range: < 20.3% to ≥32.0%) was found to be an independent predictor of subsequent CRC risk after a negative colonoscopy, findings that were consistent for proximal and distal cancers, and irrespective of patient sex (18).

However, ADR is highly variable among endoscopists and across practices (18–21). It remains to be determined whether there is threshold for the maximum benefit of ADR, where we may see no further protective benefit of a very high ADR. The answer to this question may hinge on why a low ADR is associated with a higher rate of interval cancers. If the explanation is simply that every missed polyp, independent of size, is a potential interval cancer, the higher the ADR, the better. However, it seems possible that a low ADR is an indirect measure of an inadequate examination of the colon, in which sizable malignant or premalignant lesions are overlooked or incompletely resected. An aspirational ADR may be closer to 50%, but caution must be exercised in not merely chasing a number because ADR has its limitations. A major limitation is that it may lead to a "one and done" practice pattern. Another limitation of ADR is that it does not capture the completeness of polyp resection. The Direct Observation of Polypectomy Skills and Cold Snare Polypectomy Assessment Tool scores are 2 validated measures of polypectomy completeness; however, data supporting the correlation between these measures and ADR are lacking (22,23). ADR also does not allow us to distinguish between nonadvanced adenomas and advanced adenomas, which is a considerable limitation given that advanced adenomas confer a higher risk of CRC incidence than nonadvanced adenomas (24). Alternative measures to ADR include mean adenomas per procedure and adenoma per colonoscopy, which have been associated with low adenoma miss rate (6). However, limited studies on outcomes restrict the use of these measures currently (25,26). It is also not known whether lowering the adenoma miss rate without increasing the ADR is associated with a reduction in interval CRC. Approaches to improving ADRs for physicians not meeting the minimum benchmarks are discussed in the section below.

Bowel preparation quality: Diagnosis of colonic lesions is dependent on adequate visualization of the colon. Inadequate bowel preparation limits visualization of the colon and is associated with up to a 47.9% adenoma miss rate (27,28). Poor preparation quality also leads to repeat procedures, increased healthcare costs, and further demands on patients and endoscopy units. Validated

Table 2. Bowel preparation scales for colonoscopy

Scale	Scoring	Application	Electronic link
Boston Bowel Preparation Scale	Minimum: 0 (very poor) Maximum: 9 (excellent)	Each segment rated: right colon (including cecum and ascending colon), transverse (includes hepatic and splenic flexures), and left colon (descending and sigmoid colon and rectum)	BBPS
Aronchick Scale	Minimum: 1 (excellent) Maximum: 5 (inadequate)	Single score for the total colon	Aronchick
Ottawa Bowel Preparation Scale[a] (by colon segment)	Minimum: 0 (excellent) Maximum: 14 (inadequate)	Each segment rated: right colon, midcolon, and rectosigmoid colon	Ottawa
Ottawa Bowel Preparation Scale[a] (total colon)	Minimum: 0 (small amount of fluid) Maximum: 2 (large amount of fluid)	Single score for the total colon	Ottawa
Harefield Cleansing Scale	Minimum: 0 (very bad) Maximum: 20 (very good)	Each segment rated: rectum and sigmoid, left, transverse, and right colon	Harefield
Chicago Bowel Preparation Scale[a] (by colon segment)	Minimum: 0 (unprepared) Maximum: 36 (excellent)	Each segment rated: right (cecum to midhepatic flexure), transverse (midhepatic flexure to midsplenic flexure), and left colon (midsplenic flexure to distal rectum)	Chicago
Chicago Bowel Preparation Scale[a] (total colon)	Minimum: 0 (little fluid) Maximum: 3 (large amount of fluid)	Single score for the total colon	Chicago

[a]There are 2 versions of both the Ottawa Preparation Scale and the Chicago Bowel Preparation Scale: one version provides a rating for a single segment of the colon, and a second version provides a score for the entire colon.

scales allow endoscopists to perform standardized scoring of bowel preparation quality at the time of the procedure (Table 2) (29). Of these, the Boston Bowel Preparation Scale has been favored for high reliability and ease of use (30,31). Adequate preparation is defined by the ability to detect polyps smaller than 5 mm after rinsing and suctioning of the colonic mucosa (13). More than 85% of colonoscopies for all indications and ≥90% of screening colonoscopies should be scored adequate or better to meet the ASGE/ACG CQI goals. We discourage the use of the term "fair" to describe the preparation quality. When poor bowel preparation precludes the examination, colonoscopy is appropriately aborted and the patient asked to return. However, there are often situations in which the examination can be completed, but the bowel preparation is still inadequate, defined as the inability to identify polyps larger than 5 mm. In both these scenarios, the only appropriate recommendation is to repeat the colonoscopy next available, within 1 year.

Inadequate preparation requires strategies around improving preparation instructions for patients and efforts to ensure that providers document preparation quality at the time of the procedure. To achieve the former, patient-focused interventions such as the implementation of detailed preparation instructions, split-dose bowel preparation, and same-day preparation have been shown to improve bowel preparation outcomes (32,33). Effective strategies to improve provider documentation of preparation quality are understudied but may include the use of prompts and templates for preparation scoring in endoscopy reports and individualized feedback about documentation deficiencies. When the preparation is adequate, and no neoplasia is detected; we recommend following a 10-year interval for repeat screening in an average-risk individual. A meta-analysis evaluating the impact of bowel preparation reported no significant difference in ADR between adequate and excellent preparations (34). These findings suggest that patients with adequate bowel preparation may be followed at guideline-recommended screening and surveillance intervals.

Cecal intubation rate: The ASGE/ACG Task Force defines cecal intubation as the passage of the colonoscope proximal to the ileocecal valve until the cecal caput, medial cecal wall, and appendiceal orifice are visualized (13). High cecal intubation rates are associated with a high ADR, a lower incidence of interval cancers, and, in particular, protection from right-sided CRC (11,35). Completion of this CQI must include both written and photograph documentation of the appendiceal orifice and ileocecal valve. The performance target is ≥90% for all colonoscopies and ≥95% for screening colonoscopies. Several devices and techniques have been introduced with the intention to increase cecal intubation rates, including variable-stiffness colonoscopes, single-balloon colonoscopy, magnetic endoscopic imaging, through-the-scope balloon devices, and water-assisted colonoscopy (36). In a 2018 review, the ASGE Technology Committee provides an overview of these methods, including a discussion of their effectiveness, safety, and cost (36). For many of these methods, the data are limited. Understanding the reason for incomplete cecal intubation may help guide the particular approach in subsequent attempts (36). There are also patient factors that may hinder the ability to reach the cecum, including low body mass index, history of hysterectomy, bowel preparation quality, anatomy, inflammation, and obstruction (37–41).

Withdrawal time: WT, the time measured from when the colonoscope reaches the cecum to the time the scope is withdrawn from the anus in the absence of polyp removal, has also been studied as a quality metric in colonoscopy. Studies have demonstrated that a WT of ≥6 minutes (minus the time to perform

polypectomy or other maneuvers) is associated with a higher detection of neoplastic lesions during colonoscopy in patients with intact colons (42) and reduces the risk of interval cancers (43). Shaukat et al. (43) found a statistically significant correlation between interval CRC and WTs shorter than 6 minutes in a large community-based study with over 76,000 colonoscopies. The authors also found an association between WT and ADR but did not find an association between ADR and interval CRC, suggesting that for practices with optimal ADRs (i.e., >25%), WT may be a more sensitive marker of quality of colonoscopy than ADR.

Despite evidence that WT ≥ 6 minutes is associated with a higher detection of CRC and a lower incidence of interval CRC, strategies to achieve WT ≥ 6 minutes are understudied. Endoscopist awareness of WT is associated with a longer WT (44,45). In addition, the use of audible timers during endoscopy and implementation of a minimal 6-minute WT policy can help increase the number of colonoscopies with benchmark WT (46,47). Beyond timeliness itself, endoscopists must focus on the endoscopic technique during withdrawal because it affects ADR independent of WT (48). WT needs to be spent washing and suctioning, distending, and looking behind folds to maximize the ADR (48). We also recognize that, similar to the limitations of ADR measurement, WT measurement can be gamed, in that an endoscopist may spend the entire WT in one segment. The current practice also often requires time stamping or manual time entry, which can also be recorded incorrectly.

Postprocedural CQIs

Postprocedural CQIs monitor complications of colonoscopy and the selection of appropriate surveillance intervals. Perforation is a rare but serious complication of colonoscopy and should occur in less than 0.2% of all colonoscopies and 0.1% of screening colonoscopies. Postpolypectomy bleeding rates should also be monitored regularly with the target incidence of less than 1% and ≤10% of bleeders requiring surgical management (13).

Selection and recommendation of appropriate surveillance intervals are critical after colonoscopy. Endoscopists must integrate findings from the colonoscopy report, the associated pathology report, relevant clinical features, and surveillance guidelines to prescribe surveillance intervals. Provider factors (e.g., low confidence about colonoscopy quality and lack of knowledge of surveillance intervals) in addition to patient factors (e.g., age, comorbidities, and poor bowel preparation) influence whether recommended surveillance intervals comply with surveillance guidelines (65, 66).

Currently, both overutilization and underutilization of colonoscopy are observed in most clinical settings (49–51). Both are undesirable—overuse exposes patients to unnecessary adverse risks of colonoscopy, whereas underuse is associated with an increased risk for high-risk adenomas and interval CRCs (52). Correcting this misbalance is challenging because it requires clinical data from various sources (often including data from other health systems) and knowledge of surveillance intervals. In addition, endoscopy reporting systems and EHRs are not currently adapted to reliably measure and prescribe surveillance intervals. There has been some success with the application of natural language processing to link findings from colonoscopy and pathology reports to accurately diagnose advanced tubular adenomas (53); however, a wide application of this technology is limited by a broad variation in endoscopy documentation systems and EHR platforms. Frequent audit of endoscopist surveillance recommendation and close attention to indication and surveillance interval in the preprocedural phase can help reduce overuse and improve appropriate use and timing of colonoscopy.

Technology, techniques, and tips to improve intraprocedure colonoscopy quality

Improving the performance of colonoscopy may be achieved through measurement and report cards, enhanced techniques (change in patient position, water exchange, and second look in the cecum), technology (high-magnification scopes, accessory devices, such as Endocuff, Endocap, and Endorings, and use of artificial intelligence [AI] software), or educational and multistep interventions (Figure 1). These are summarized in Table 3.

Measurement, endoscopist feedback, and report cards

Awareness of quality metrics among individuals and endoscopy practices is crucial to ensuring adequate performance. Several studies have demonstrated improvement with feedback and monitoring of endoscopists (45,54). Some strategies to improve colonoscopy technique and efficiency include having recorded or observed procedures, computer software that measures image resolution, and scorecards with quality measures. A representative of the scorecards used in our practice is shown in Table 4. Feedback measures both make endoscopists aware of how their performance compares with recommended goals for colonoscopy and help track improvement. We recommend that such feedback should be provided quarterly and more frequently for providers not meeting benchmarks. Most of the commercially available endoscopic reporting softwares or templated notes allow for customizable data queries to be run quarterly. We recommend training and assigning a dedicated person, such as the quality manager or nurse manager, to perform these automated reports and calculate ADRs (when not automated) in a uniform manner for all endoscopists in the practice. The dedicated staff member should work closely with a physician champion to collate and disseminate the reports to endoscopists, with an action plan for low performers.

Endoscopic techniques to improve ADR

Endoscopic techniques that increase mucosal visualization during colonoscopy include water-aided colonoscopy, retroflexion in the cecum, and patient position change. Water-aided colonoscopy techniques (e.g., water exchange and water immersion) have gained attention in recent years and have a variable impact on ADR in studies (55,56). In a recent systematic review and meta-analysis including 17 randomized controlled trials, water exchange was associated with higher overall ADR than air insufflation (odds ratio [OR], 1.40; 95% confidence interval [CI], 1.22–1.62) and water immersion (OR, 1.31; 95% CI, 1.12–1.55) (56). The use of water exchange and water immersion was associated with lower insertion pain and more unsedated examinations.

Right-sided retroflexion in the cecum results in a small but statistically significant increase in adenoma yield (57–59). A systematic review including 8 studies that assessed the effectiveness of position changes during colonoscopy withdrawal resulted in mixed evidence for this technique but was limited by a lack of statistical combining of the data (60). A more recent meta-analysis to compare the efficacy of different strategies for adenoma detection demonstrated that low-cost optimizing of

Table 3. Strategies to improve colonoscopy performance

	Examples	Strength of evidence
Technique	Water exchange	Moderate
	Changing patient position during withdrawal	Limited
	Second look in the cecum	Limited
	Retroflexion in the cecum	Limited
Technology	High-magnification scopes	Moderate
	Distal devices (Endorings, Endocuff, Endocap, and G-EYE systems)	Moderate
	Enhanced imaging techniques (chromoendoscopy, narrowband imaging, flexible spectral imaging color enhancement, and blue laser imaging)	Moderate
	AI software	Limited
Audit and feedback	Report cards	Moderate
	Video recording of colonoscopy	Limited
	Posting/publishing ADRs	Limited
Multiple interventions	Educational courses	Limited
	Mandating longer withdrawal and enhanced inspection	
	Videos of high performers and techniques	
	Proctoring	

ADR, adenoma detection rate; AI, artificial intelligence.

existing resources, which included water-aided colonoscopy, second observer, and dynamic position change, resulted in an increase in ADR when compared with high-definition colonoscopy (61). Each of these methods can add to the overall procedure time, which has hindered implementation and consistent use in many settings. We recommend that each practice reviews the available strategies and customizes a plan aimed at improving ADRs among low performers. The plan should best fit the specific needs and available resources of the practice, which may require the use of more than one available technique, such as water exchange and changing patient position during withdrawal.

Technology

There are multiple endoscopic technology innovations aimed at exposing more mucosa during inspection, improving visibility and polyp detection (55,62). Newer generation colonoscopes have a wider field of view of 170° (e.g., Olympus CF-190) compared with 140-degree field of view of older colonoscopes (63,64). The newer generation of scopes also comes with higher magnification and ability to near-focus (63,64). Colonoscopes with multiple cameras on the scope tip are available that expose the additional colonic mucosa (65). Short-turn radius colonoscopes allow for easy retroflexion and exposure of proximal colon folds during withdrawal (66). Other exciting advances have been made in the use of distal attachment devices, such as the Endorings, Endocap, Endocuff, and G-EYE systems (67–72). Finally, the use of AI with colonoscopy has been shown to improve polyp and

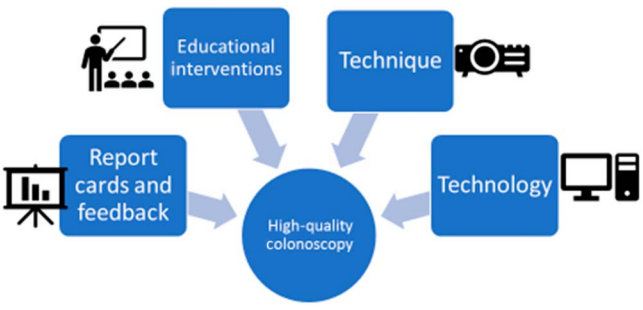

Figure 1. Interventions to improve intraprocedure colonoscopy quality.

Table 4. Sample endoscopist report card

Endoscopist ID: 21314566	Period: Q1 2018
Total no. of colonoscopies performed	300
Total no. of screening colonoscopies performed	100
Complete colonoscopies (excluding cases because of poor preparation)	295 (98%)
ADR (for screening colonoscopy)	31%
WT (procedures where no polypectomy or biopsies performed), min	8.2 ± 1.15
No. of colonoscopies with inadequate bowel preparation	5 (2%)

ADR, adenoma detection rate; AI, artificial intelligence.

adenoma detection and represents a growing area of active research. AI software can aid in exposing more colonic mucosa but also report the percentage of mucosa visualized, preparation quality, polyp size, and polyp histology (73–78). In the future, we expect AI technology to be integrated within colonoscopes for enhanced polyp detection (79). Although there is a lot of enthusiasm for technology, it comes at a financial cost to the system and is not a substitute for proper technique.

In a recent comprehensive systematic review, Facciorusso et al. (61) compared the efficacy of add-on devices (Endocap, Endorings, Endocuff, and G-EYE), enhanced imaging techniques (chromoendoscopy, narrowband imaging, flexible spectral imaging color enhancement, and blue laser imaging), new scopes (full-spectrum endoscopy, extra-wide-angle-view colonoscopy, and dual focus), and low-cost optimizing existing resources (water-aided colonoscopy, second observer, and dynamic position change) alone or in combination with high-definition colonoscopy or each other in improving ADR. They reported that low-cost optimizing existing resources (OR, 1.29; 95% CI, 1.17–1.43), enhanced imaging techniques (OR, 1.21; 95% CI, 1.09–1.35), and add-on devices (OR, 1.18; 95% CI, 1.07–1.29) were associated with a moderate increase in ADR compared with high-definition colonoscopy; there was low to moderate confidence in estimates. The use of newer scopes was not associated with significant increases in ADR compared with high-definition colonoscopy (OR, 0.98; 95% CI, 0.79–1.21). The authors concluded that no specific technology was consistently superior to others in improving ADR, advanced ADR, adenomas per colonoscopy, or mean adenomas per patient (61). Of the data available, Endocuff has the most consistent (although small) impact on ADR (80,81). As an overall caution, however, these new devices and technologies are currently experimental at most, and existing studies are limited by generalizability, endoscopist's bias, and incomplete controlling for inspection time, which can contribute to improvements in ADR. Strong operator-dependent skills remain the backbone of high ADRs. For low performers, we recommend that the technique be evaluated and addressed first before trying external devices.

Educational and multistep interventions

Mandating a longer WT alone was not associated with improved polyp detection rates (82). However, in a study by Barclay and colleagues, in which an audible timer was used during withdrawal (implementing an 8-minute WT) in addition to enhanced inspection techniques, ADR increased by 50% compared with baseline, a statistically significant finding (ADR 37.8% vs 23.3%; $P < 0.001$) (46). Wallace et al. demonstrated a significant improvement in ADR with multiple educational and system interventions, such as providing endoscopist report cards, education on how to achieve higher ADR and colon inspection techniques, and posting deidentified ADRs of physicians in the endoscopy unit (ADR 36%–47%; $P < 0.001$); these improvements were sustained 6 months later (83,84). Others have also demonstrated favorable improvements in polyp detection, adenoma detection, and WT with education and feedback that is sustained one year or longer (45,85–87). For low performers, we recommend evaluation of withdrawal technique with emphasis on cleaning, suctioning, looking behind folds, and going back and forth during withdrawal. The use of audible timers and emphasis on segmental inspection are also recommended.

SUMMARY

Quality indicators in colonoscopy are available for practitioners and institutions to review, implement, and monitor. The goal is to ensure that patients maximally benefit from screening colonoscopies from both the detection of early CRC and the prevention of cancer via the resection of precancerous lesions. Every provider and practice must make a commitment to performing high-quality colonoscopy and implement and monitor quality metrics. The first step in this commitment is provider feedback through audits and report cards. There are a variety of tools available to assist low performers in improving their quality indicators that range from distal attachment devices to education and feedback. Although technology can help, it is not a substitute for proper technique. The impact of these efforts on patient outcomes is an important area of future research.

CONFLICTS OF INTEREST

Guarantor of the article: Aasma Shaukat, MD, MPH.

Specific author contributions: F.M.: concept and design, drafting of the manuscript, critical revision of the manuscript, and approval of the final draft submitted. A.S.: concept and design, overall supervision, drafting of the manuscript, critical revision of the manuscript, and approval of the final draft submitted.

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REFERENCES

1. I Data Reserach (https://idataresearch.com/an-astounding-19-million-colonoscopies-are-performed-annually-in-the-united-states/). Accessed August 22, 2019.
2. American Cancer Society. Colorectal Cancer Facts & Figures 2017–2019. Atlanta, GA: American Cancer Society; 2017.
3. Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. N Engl J Med 2012; 366(8):687–96.
4. Nishihara R, Wu K, Lochhead P, et al. Long-term colorectal-cancer incidence and mortality after lower endoscopy. N Engl J Med 2013; 369(12):1095–105.
5. Calderwood AH, Jacobson BC. Colonoscopy quality: Metrics and implementation. Gastroenterol Clin North Am 2013;42(3):599–618.
6. Zhao S, Wang S, Pan P, et al.. Magnitude, risk factors, and factors associated with adenoma miss rate of tandem colonoscopy: A systematic review and meta-analysis. Gastroenterology 2019;156(6):1661–74.e11.
7. Morris EJ, Rutter MD, Finan PJ, et al. Post-colonoscopy colorectal cancer (PCCRC) rates vary considerably depending on the method used to calculate them: A retrospective observational population-based study of PCCRC in the English national health service. Gut 2015;64(8):1248–56.
8. Bressler B, Paszat LF, Chen Z, et al. Rates of new or missed colorectal cancers after colonoscopy and their risk factors: A population-based analysis. Gastroenterology 2007;132(1):96–102.
9. Singh H, Nugent Z, Demers AA, et al. Rate and predictors of early/missed colorectal cancers after colonoscopy in manitoba: A population-based study. Am J Gastroenterol 2010;105(12):2588–96.

10. Rabeneck L, Paszat LF, Saskin R. Endoscopist specialty is associated with incident colorectal cancer after a negative colonoscopy. Clin Gastroenterol Hepatol 2010;8(3):275–9.
11. Baxter NN, Sutradhar R, Forbes SS, et al. Analysis of administrative data finds endoscopist quality measures associated with postcolonoscopy colorectal cancer. Gastroenterology 2011;140(1):65–72.
12. Kim SY, Kim HS, Park HJ. Adverse events related to colonoscopy: Global trends and future challenges. World J Gastroenterol 2019;25(2):190–204.
13. Rex DK, Schoenfeld PS, Cohen J, et al. Quality indicators for colonoscopy. Am J Gastroenterol 2015;110(1):72–90.
14. Church J. Adenoma detection rate and the quality of colonoscopy: The sword has two edges. Dis Colon Rectum 2008;51(5):520–3.
15. Corley DA, Jensen CD, Marks AR. Can we improve adenoma detection rates? A systematic review of intervention studies. Gastrointest Endosc 2011;74(3):656–65.
16. Kaminski MF, Regula J, Kraszewska E, et al. Quality indicators for colonoscopy and the risk of interval cancer. N Engl J Med 2010;362(19): 1795–803.
17. Rex DK, Petrini JL, Baron TH, et al. Quality indicators for colonoscopy. Am J Gastroenterol 2006;101(4):873–85.
18. Corley DAJ, Christopher D, Marks AR, et al. Physician adenoma detection rate variability and subsequent colorectal cancer risk following a negative colonoscopy. Gastroenterology 2013;144(5):S2–S3.
19. Boroff ES, Disbrow M, Crowell MD, et al. Adenoma and polyp detection rates in colonoscopy according to indication. Gastroenterol Res Pract 2017;2017:7207595.
20. Corley DA, Jensen CD, Marks AR, et al. Variation of adenoma prevalence by age, sex, race, and colon location in a large population: Implications for screening and quality programs. Clin Gastroenterol Hepatol 2013;11(2): 172–80.
21. Rex DK, Cutler CS, Lemmel GT, et al. Colonoscopic miss rates of adenomas determined by back-to-back colonoscopies. Gastroenterology 1997;112(1):24–8.
22. Duloy AM, Keswani RN. Assessing the quality of polypectomy and teaching polypectomy. Gastrointest Endosc Clin N Am 2019;29(4): 587–601.
23. Duloy AM, Kaltenbach TR, Keswani RN. Assessing colon polypectomy competency and its association with established quality metrics. Gastrointest Endosc 2018;87(3):635–44.
24. Click B, Pinsky PF, Hickey T, et al. Association of colonoscopy adenoma findings with long-term colorectal cancer incidence. JAMA 2018;319(19): 2021–31.
25. Denis B, Sauleau EA, Gendre I, et al. The mean number of adenomas per procedure should become the gold standard to measure the neoplasia yield of colonoscopy: A population-based cohort study. Dig Liver Dis 2014;46(2):176–81.
26. Gessl I, Waldmann E, Penz D, et al. Evaluation of adenomas per colonoscopy and adenomas per positive participant as new quality parameters in screening colonoscopy. Gastrointest Endosc 2019;89(3): 496–502.
27. Lebwohl B, Kastrinos F, Glick M, et al. The impact of suboptimal bowel preparation on adenoma miss rates and the factors associated with early repeat colonoscopy. Gastrointest Endosc 2011;73(6): 1207–14.
28. Chokshi RV, Hovis CE, Hollander T, et al. Prevalence of missed adenomas in patients with inadequate bowel preparation on screening colonoscopy. Gastrointest Endosc 2012;75(6):1197–203.
29. Kastenberg D, Bertiger G, Brogadir S. Bowel preparation quality scales for colonoscopy. World J Gastroenterol 2018;24(26):2833–43.
30. Heron V, Parmar R, Menard C, et al. Validating bowel preparation scales. Endosc Int Open 2017;5(12):E1179–88.
31. Calderwood AH, Jacobson BC. Comprehensive validation of the Boston bowel preparation scale. Gastrointest Endosc 2010;72(4):686–92.
32. Guo X, Yang Z, Zhao L, et al. Enhanced instructions improve the quality of bowel preparation for colonoscopy: A meta-analysis of randomized controlled trials. Gastrointest Endosc 2017;85(1):90–7.e6.
33. Bucci C, Zingone F, Schettino P, et al. Same-day regimen as an alternative to split preparation for colonoscopy: A systematic review with meta-analysis. Gastroenterol Res Pract 2019;2019:7476023.
34. Clark BT, Rustagi T, Laine L. What level of bowel prep quality requires early repeat colonoscopy: Systematic review and meta-analysis of the impact of preparation quality on adenoma detection rate. Am J Gastroenterol 2014;109(11):1714–23; quiz 24.
35. Lund M, Trads M, Njor SH, et al. Quality indicators for screening colonoscopy and colonoscopist performance and the subsequent risk of interval colorectal cancer: A systematic review. JBI Database Syst Rev Implement Rep 2019;17(11):2265–300.
36. Committee AT, Trindade AJ, Lichtenstein DR, et al. Devices and methods to improve colonoscopy completion (with videos). Gastrointest Endosc 2018;87(3):625–34.
37. Hafner S, Zolk K, Radaelli F, et al. Water infusion versus air insufflation for colonoscopy. Cochrane Database Syst Rev 2015(5):CD009863.
38. Gupta M, Holub JL, Eisen G. Do indication and demographics for colonoscopy affect completion? A large national database evaluation. Eur J Gastroenterol Hepatol 2010;22(5):620–7.
39. Pullens HJ, Siersema PD. Quality indicators for colonoscopy: Current insights and caveats. World J Gastrointest Endosc 2014;6(12):571–83.
40. Arya V, Singh S, Agarwal S, et al. Position change during colonoscopy improves caecal intubation rate, mucosal visibility, and adenoma detection in patients with suboptimal caecal preparation. Prz Gastroenterol 2017;12(4):296–302.
41. East JM. Effect of a proprietary intraluminal stiffening wire device on cecal intubation time and rate with used colonoscopes; a randomized, controlled trial. BMC Res Notes 2013;6:48.
42. Barclay RL, Vicari JJ, Doughty AS, et al. Colonoscopic withdrawal times and adenoma detection during screening colonoscopy. N Engl J Med 2006;355(24):2533–41.
43. Shaukat A, Rector TS, Church TR, et al. Longer withdrawal time is associated with a reduced incidence of interval cancer after screening colonoscopy. Gastroenterology 2015;149(4):952–7.
44. Vavricka SR, Sulz MC, Degen L, et al. Monitoring colonoscopy withdrawal time significantly improves the adenoma detection rate and the performance of endoscopists. Endoscopy 2016;48(3):256–62.
45. Nielsen AB, Nielsen OH, Hendel J. Impact of feedback and monitoring on colonoscopy withdrawal times and polyp detection rates. BMJ Open Gastroenterol 2017;4(1):e000142.
46. Barclay RL, Vicari JJ, Greenlaw RL. Effect of a time-dependent colonoscopic withdrawal protocol on adenoma detection during screening colonoscopy. Clin Gastroenterol Hepatol 2008;6(10):1091–8.
47. Baker SL, Miller RA, Creighton A, et al. Effect of 6-minute colonoscopy withdrawal time policy on polyp detection rate in a community hospital. Gastroenterol Nurs 2015;38(2):96–9.
48. Lee RH, Tang RS, Muthusamy VR, et al. Quality of colonoscopy withdrawal technique and variability in adenoma detection rates (with videos). Gastrointest Endosc 2011;74(1):128–34.
49. Saini SD, Powell AA, Dominitz JA, et al. Developing and testing an electronic measure of screening colonoscopy overuse in a large integrated healthcare system. J Gen Intern Med 2016;31(Suppl 1):53–60.
50. Murphy CC, Lewis CL, Golin CE, et al. Underuse of surveillance colonoscopy in patients at increased risk of colorectal cancer. Am J Gastroenterol 2015;110(5):633–41.
51. Murphy CC, Sandler RS, Grubber JM, et al. Underuse and overuse of colonoscopy for repeat screening and surveillance in the Veterans health administration. Clin Gastroenterol Hepatol 2016;14(3):436–44.e1.
52. Atkin W, Wooldrage K, Brenner A, et al. Adenoma surveillance and colorectal cancer incidence: A retrospective, multicentre, cohort study. Lancet Oncol 2017;18(6):823–34.
53. Imler TD, Morea J, Kahi C, et al. Multi-center colonoscopy quality measurement utilizing natural language processing. Am J Gastroenterol 2015;110(4):543–52.
54. Gurudu SR, Boroff ES, Crowell MD, et al. Impact of feedback on adenoma detection rates: Outcomes of quality improvement program. J Gastroenterol Hepatol 2018;33(3):645–9.
55. Dik VK, Moons LM, Siersema PD. Endoscopic innovations to increase the adenoma detection rate during colonoscopy. World J Gastroenterol 2014; 20(9):2200–11.
56. Fuccio L, Frazzoni L, Hassan C, et al. Water exchange colonoscopy increases adenoma detection rate: A systematic review with network meta-analysis of randomized controlled studies. Gastrointest Endosc 2018;88(4):589–97.e11.
57. Hewett DG, Rex DK. Miss rate of right-sided colon examination during colonoscopy defined by retroflexion: An observational study. Gastrointest Endosc 2011;74(2):246–52.
58. Miyamoto H, Naoe H, Oda Y, et al. Impact of retroflexion in the right colon after repeated forward-view examinations. JGH Open 2018;2(6):282–7.

59. Chandran S, Parker F, Vaughan R, et al. Right-sided adenoma detection with retroflexion versus forward-view colonoscopy. Gastrointest Endosc 2015;81(3):608–13.
60. Zhao SB, Wan H, Fu HY, et al. Quantitative assessment of the effect of position changes during colonoscopy withdrawal. J Dig Dis 2016;17(6): 357–65.
61. Facciorusso A, Triantafyllou K, Murad MH, et al. Compared abilities of endoscopic techniques to increase colon adenoma detection rates: A network meta-analysis. Clin Gastroenterol Hepatol 2019;17(12): 2439–54.e25.
62. Gomez V, Racho RG, Heckman MG, et al. High-definition white-light (HDWL) colonoscopy and higher adenoma detection rate and the potential for paradoxical over surveillance. Dig Dis Sci 2014;59(11): 2749–56.
63. ASGE Technology Committee. High-definition and high-magnification endoscopes. Gastrointest Endosc 2014;80(6):919–27.
64. Konda V, Chauhan SS, Abu Dayyeh BK, et al. Endoscopes and devices to improve colon polyp detection. Gastrointest Endosc 2015;81(5):1122–9.
65. Gralnek IM, Siersema PD, Halpern Z, et al. Standard forward-viewing colonoscopy versus full-spectrum endoscopy: An international, multicentre, randomised, tandem colonoscopy trial. Lancet Oncol 2014; 15(3):353–60.
66. McGill SK, Kothari S, Friedland S, et al. Short turn radius colonoscope in an anatomical model: Retroflexed withdrawal and detection of hidden polyps. World J Gastroenterol 2015;21(2):593–9.
67. Dik VK, Gralnek IM, Segol O, et al. Multicenter, randomized, tandem evaluation of EndoRings colonoscopy—Results of the CLEVER study. Endoscopy 2015;47(12):1151–8.
68. Halpern Z, Gross SA, Gralnek IM, et al.. Comparison of adenoma detection and miss rates between a novel balloon colonoscope and standard colonoscopy: A randomized tandem study. Endoscopy 2015; 47(4):301.
69. Gkolfakis P, Tziatzios G, Facciorusso A, et al. Meta-analysis indicates that add-on devices and new endoscopes reduce colonoscopy adenoma miss rate. Eur J Gastroenterol Hepatol 2018;30(12):1482–90.
70. Gkolfakis P, Tziatzios G, Spartalis E, et al. Colonoscopy attachments for the detection of precancerous lesions during colonoscopy: A review of the literature. World J Gastroenterol 2018;24(37):4243–53.
71. Hassan C, Senore C, Manes G, et al. Diagnostic yield and miss rate of EndoRings in an organized colorectal cancer screening program: The SMART (study methodology for ADR-related technology) trial. Gastrointest Endosc 2019;89(3):583–90.e1.
72. Rex DK, Kessler WR, Sagi SV, et al. Impact of a ring-fitted cap on insertion time and adenoma detection: A randomized controlled trial. Gastrointest Endosc 2020;91:115–20.
73. Chao WL, Manickavasagan H, Krishna SG. Application of artificial intelligence in the detection and differentiation of colon polyps: A technical review for physicians. Diagnostics (Basel) 2019;9(3).
74. Kudo SE, Misawa M, Mori Y, et al. Artificial intelligence-assisted system improves endoscopic identification of colorectal neoplasms. Clin Gastroenterol Hepatol 2019. [Epub ahead of print February 9, 2006.]
75. Vinsard DG, Mori Y, Misawa M, et al. Quality assurance of computer-aided detection and diagnosis in colonoscopy. Gastrointest Endosc 2019; 90(1):55–63.
76. Wang P, Berzin TM, Glissen Brown JR, et al. Real-time automatic detection system increases colonoscopic polyp and adenoma detection rates: A prospective randomised controlled study. Gut 2019;68(10): 1813–9.
77. Wang P, Xiao X, Glissen Brown JR, et al. Development and validation of a deep-learning algorithm for the detection of polyps during colonoscopy. Nat Biomed Eng 2018;2(10):741–8.
78. Yamada M, Saito Y, Imaoka H, et al. Development of a real-time endoscopic image diagnosis support system using deep learning technology in colonoscopy. Sci Rep 2019;9(1):14465.
79. Kudo SE, Mori Y, Misawa M, et al. Artificial intelligence and colonoscopy: Current status and future perspectives. Dig Endosc 2019;31(4):363–71.
80. Chin M, Karnes W, Jamal MM, et al. Use of the endocuff during routine colonoscopy examination improves adenoma detection: A meta-analysis. World J Gastroenterol 2016;22(43):9642–9.
81. Williet N, Tournier Q, Vernet C, et al. Effect of endocuff-assisted colonoscopy on adenoma detection rate: meta-analysis of randomized controlled trials. Endoscopy 2018;50(9):846–60.
82. Sawhney MS, Cury MS, Neeman N, et al. Effect of institution-wide policy of colonoscopy withdrawal time $>$ or $=$ 7 minutes on polyp detection. Gastroenterology 2008;135(6):1892–8.
83. Coe SG, Crook JE, Diehl NN, et al. An endoscopic quality improvement program improves detection of colorectal adenomas. Am J Gastroenterol 2013;108(2):219–26; quiz 27.
84. Ussui V, Coe S, Rizk C, et al. Stability of increased adenoma detection at colonoscopy. Follow-up of an endoscopic quality improvement program-EQUIP-II. Am J Gastroenterol 2015;110(4):489–96.
85. Bugajski M, Rupinski M, Wieszczy P, et al. Key performance measures for colonoscopy in the polish colonoscopy screening program. Endoscopy 2019;51(9):858–65.
86. Bugajski M, Wieszczy P, Pisera M, et al. Effectiveness of digital feedback on patient experience and 30-day complications after screening colonoscopy: A randomized health services study. Endosc Int Open 2019; 7(4):E537–44.
87. Kaminski MF, Bugajski M, Bisschops R. Adoption of colonoscopy quality measures across Europe by Riemann et al. United Eur Gastroenterol J 2018;6(7):1108.