



Interventions to improve adenoma detection rates for colonoscopy

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Colonoscopy is one of the most common medical procedures, with over 19 million performed annually in the United States.¹ Currently, most colorectal cancer (CRC) screening in the United States is done with colonoscopy,² and colonoscopy is considered by many to be the screening test of choice, because it allows for the prevention of CRC through both detection and removal of asymptomatic adenomas.^{3,4}

Colonoscopic screening is estimated to reduce CRC incidence and mortality by 69% (95% confidence interval [CI], 23%-88%) and 68% (95% CI, 57%-77%), respectively.⁵ Despite its common use for CRC screening, colonoscopy is imperfect and has variable quality in the United States.⁶ Adenoma miss rates are between 9% and 26% in tandem colonoscopy studies.⁷ In addition, 2.1% to 7.7% of CRCs diagnosed are interval cancers that develop after screening colonoscopy but before subsequent surveillance is indicated.⁸⁻¹³ Therefore, over the last 2 decades, increasing emphasis has been placed on high-value care through *high-quality colonoscopy*.

Kaminski et al¹⁴ demonstrated that the adenoma detection rate (ADR), defined as the proportion of average-risk patients undergoing screening colonoscopy in whom an adenoma is found, was an independent predictor of the risk of interval CRC. This was confirmed by Corley et al in 2014,¹⁵ with each 1% increase in ADR associated with a 3% decrease in interval CRC incidence and a 5% decrease in interval CRC mortality.

In 2015, the American Society for Gastrointestinal Endoscopy (ASGE) and American College of Gastroenterology published an updated list of quality indicators for colonoscopy.¹⁶ Current benchmarks are 30% for men and 20% for women 50 years of age and older, for a blended rate of 25%.¹⁷ However, it is not uncommon for endoscopists to fall below these benchmarks. For example, among 136 endoscopists at a large U.S. health maintenance organization, over 40% of endoscopists studied had a blended gender ADR below 25%.¹⁵

Therefore, the purpose of this review is to review the evidence on interventions to improve ADR.

METHODS

The purpose of this document is to augment the previously developed endoscopy quality indicator publications first drafted in 2006 by the joint task force on quality in endoscopy of the ASGE/American College of Gastroenterology and that integrated new data in 2014. The ASGE Quality Assurance in Endoscopy Committee outlined the proposal, and the methodology was reviewed with an expert evidence-based medicine methodologist (M.H.M.). Clinically relevant questions¹⁸ were selected to guide the systematic literature review.¹⁹ All clinically relevant questions were written and approved by the Quality Assurance in Endoscopy Committee members and designed to conjure ameliorating interventions to the previously prioritized quality indicators.

To facilitate a comprehensive search, all clinically relevant questions were collapsed into a single search strategy that was designed and executed by a medical librarian. We searched PubMed and Embase from 1990 to September 2021. Search criteria were adult and pediatric human subjects only, English language articles, published articles, and studies with a comparator (randomized controlled, controlled clinical, case-control, and cohort trials). We also included review articles and prior systematic reviews and meta-analyses.

Key words used were adenoma detection rate, adenoma miss rate, adenoma per colonoscopy, mean number of adenomas, colonoscopy *and* quality indicators, water exchange, report cards, endoscopist feedback, bowel preparation quality, split-dose preparation, same-day bowel preparation, withdrawal time, retroflexion within the cecum, second-look cecum, financial

incentives, educational interventions, and video recording. Given the extensive amount of literature on colonoscopy quality indicators, we focused on ADR as the primary outcome. The search output was selected by Quality Assurance in Endoscopy Committee members and was summarized narratively.

Interventions to improve ADR were broadly categorized into 4 categories of interventions related to techniques, technology, systemic interventions, and education and feedback. Interventions were framed around key questions regarding these categories as follows:

- Techniques
 - Does water assistance during colonoscopy compared with gas insufflation increase adenoma detection?
 - Does lengthening withdrawal time during colonoscopy increase adenoma detection?
 - Does a second look in the right-sided colon and cecum, with either a second forward look or retroflexion in the cecum, during colonoscopy compared with single forward view increase adenoma detection?
 - Does any change in patient position during withdrawal compared with not changing patient position during withdrawal increase adenoma detection?
- Technology
 - Do distal attachment devices compared with standard colonoscopy improve adenoma detection?
 - Do enhanced imaging technologies improve adenoma detection compared with standard white-light colonoscopy?
 - Do computer-aided detection (CADe) and artificial intelligence technologies improve adenoma detection compared with standard colonoscopy?
- Interventions (facility level, provider level)
 - Does split-dose bowel preparation before colonoscopy compared with day-before preparation increase adenoma detection?
 - Does same-day bowel preparation before colonoscopy compared with split-dose preparation increase adenoma detection?
 - Does being observed and/or recorded compared with not being observed and/or recorded increase adenoma detection?
 - Does the involvement of a second observer examining the colon for colon polyps compared with the endoscopist alone increase adenoma detection?
- Endoscopist education and feedback
 - Do physician report cards compared with no report cards increase adenoma detection?
 - Do focused educational interventions compared with standard education increase adenoma detection?
 - Do financial incentives compared with no financial incentives increase adenoma detection?
 - Does public reporting compared with no public reporting increase adenoma detection?

INTERVENTIONS TO IMPROVE THE QUALITY OF ADR FOR COLONOSCOPY

Individual interventions are reported below by key questions and summarized in [Table 1](#).

Techniques

Does water assistance during colonoscopy compared with gas insufflation increase adenoma detection? Water-assisted colonoscopy includes water immersion (WI; water infusion during insertion) and water exchange (WE; water infused and exchanged during insertion) with subsequent suctioning of water with gas insufflation during withdrawal (immersion and exchange). Water-assisted techniques are low-cost methods proposed to increase adenoma detection.²⁰ A Cochrane review concluded that ADR was improved with water-assisted (including WI and WE) colonoscopy compared with air insufflation (36% vs 31%, respectively).²¹ By providing salvage cleansing during insertion, WE may maximize the cleanliness of the colonic lumen, thus making it superior to WI and air insufflation in adenoma detection.²² A meta-analysis of 5 randomized controlled trials confirmed the hypothesis that WE is superior to WI in improving the ADR.²³ In an international modified Delphi review that included 55 expert endoscopists, 88% agreed that WE colonoscopy was associated with higher adenoma detection than gas insufflation and that WE was associated with a 2-minute increase in withdrawal time compared with gas insufflation (97% agreement).²⁴

Further, 2 meta-analyses demonstrated that WE resulted in the highest ADR compared with WI, air insufflation, and carbon dioxide insufflation.^{25,26} In the network meta-analysis by Fuccio et al,²⁶ including 17 trials and 10,350 patients, the raw estimates for overall ADR were 41.7% for WE, 34.4% for WI, 30.2% air insufflation, and 31.1% for carbon dioxide insufflation. WE requires time for the removal of infused water, residual air, and debris, thus increasing the insertion time (3-5 additional minutes). However, withdrawal time was similar to other techniques.²⁶

A more recent systematic review and network meta-analysis of 21 studies comparing WE with the distal add-on devices ENDOCUFF (Olympus America; Arc Medical Design Ltd, Leeds, England) or EndoCap to air insufflation concluded that WE may be the modality of choice to maximally improve ADR and advanced ADR (AADR).²⁷ The analysis determined that both WE and ENDOCUFF significantly increased the ADR, whereas EndoCap was found to have no impact on ADR. However, only WE, but not the ENDOCUFF or EndoCap, significantly increased the AADR.²⁷

- Summary: WE increases ADR by up to 10 percentage points.

Does lengthening withdrawal time during colonoscopy increase adenoma detection? The average withdrawal time in negative screening colonoscopies is recommended to be at least 6 minutes.²⁸ Although several

TABLE 1. Summary on interventions to improve ADR

Intervention	Compared with	Absolute increase in adenoma detection	Comments
<i>Technique</i>			
Water assistance	CO ₂ /air insufflation	6% water immersion 10% for water exchange	Water exchange increases insertion time but withdrawal time same as other techniques
Lengthening withdrawal time	<6 min	9% for 9-min WT compared with 6 min	Evidence supports emphasizing training in withdrawal technique rather than time
Retroflexion in cecum	No retroflexion	17% for right-sided adenomas	Overall success rate 91%, adverse vents .03%
Second look, either retroflexion in the cecum or second forward look in the proximal colon	Single forward look	10% for all adenomas, 5% for right-sided adenomas	Second forward look improves adenoma detection; no difference in retroflexed or straightforward second look
Dynamic change in patient position	No change in position	7%	Adequate distention during position changes is key, particularly with excellent preparation
<i>Technology</i>			
Distal attachment devices	Standard colonoscopy	5%-11%	May reduce procedure time
Enhanced imaging technology (narrow-band imaging, i-SCAN, linked-color imaging, blue-laser imaging, chromoendoscopy, and Methylene Blue-MMX (Cosmo Pharmaceuticals, Dublin, Ireland))	Standard or high definition white-light colonoscopy	5% to 18% absolute improvement in adenoma detection	Narrow-band imaging with 190 colonoscopes is superior to white-light colonoscopy
Computer aided detection technologies	Standard colonoscopy	10%-12% in adenoma, .2 in adenoma per colonoscopy	Added benefit of polyp histology recognition
<i>Systematic interventions</i>			
Split-dose bowel preparation	Day-before bowel preparation	26%	Also improvement in detection rates of advanced adenoma and sessile serrated lesions
Same-day bowel preparation	Split-dose bowel preparation	No improvement	
Video recording of colonoscopy	No recording	No improvement	Underpowered study, but may be of value in low performers
Nurse assigned to observe colonoscopy monitor	No observation	19%	
<i>Education and feedback</i>			
Physician report cards	No report cards	10%-15%	Benefit seen in low and high performers
Focused educational interventions	No education	29% for ADR, 39% for proximal ADR	Combination of education, teaching, video recording, and feedback
Financial incentives	No financial incentives	0%-3%	Amount of financial incentives studied did not matter
Public reporting of ADR	No public reporting	45% increase in ADR, 25% in advanced ADR	

ADR, Adenoma detection rate; WT, withdrawal time.

studies have shown that increasing withdrawal time increases the ADR,²⁹⁻³⁴ others have shown no benefit to lengthening the withdrawal time.^{35,36} The reason for these mixed results is likely differences in withdrawal technique. Withdrawal time is a surrogate for careful inspection using adequate withdrawal techniques, and this time is meant to be spent washing and suctioning, looking behind folds and performing segmental inspection.³⁷ However, withdrawal time measurement

can be misleading and not representative of adequate inspection of the entire colon.

Although existing guidelines recommend a minimal withdrawal time of 6 minutes, data suggest a longer withdrawal time may be more beneficial. In 1 study, a minimum 8-minute withdrawal time was associated with an increased ADR compared with a minimum withdrawal time of 6 minutes.³⁸ A recent multicenter randomized controlled trial demonstrated that increasing the withdrawal time from 6

to 9 minutes significantly improved the ADR (27.1% vs 36.6%, $P = .001$), especially in the right side of the colon.³⁹ Overall, the available data would suggest that increasing withdrawal time with a commensurate focus on high-quality inspection technique will lead to increases in ADR.

- Summary: Lengthening withdrawal time to 8 to 9 minutes with enhanced inspection techniques increases ADR by up to 9 percentage points.

Does a second look in the right-sided colon and cecum, with either a second forward look or retroflexion in the cecum, during colonoscopy compared with single forward view increase adenoma detection?

Missed and recurrent adenomas are more likely to occur in the right-sided colon.⁴⁰ Tandem colonoscopy studies have reported a significant adenoma miss rate, which may explain the disproportionately high number of postcolonoscopy colon cancers in the proximal colon.⁷ This also demonstrates the importance of a second examination of the proximal colon, whether through a second forward view or a retroflexed view. Several studies have examined the yield of a second forward-view examination of the right-sided colon to increase the ADR.⁴¹⁻⁴⁵ This technique involves withdrawing the colonoscope to the hepatic flexure and advancing into the cecum while performing a thorough inspection and is appealing because it requires no additional equipment, minimal additional procedure time, and, unlike retroflexion in the right-sided colon, carries minimal additional procedure risk.

A pooled analysis of 4 studies found that a second forward view of the right-sided colon increased the right-sided ADR by 10% compared with standard colonoscopy (33.6% vs 26.7%). In the same systematic review, 4 studies examined the adenoma miss rate of standard colonoscopy using a second forward view in the right-sided colon and found that the pooled estimate of the adenoma miss rate with standard withdrawal was 13.3% compared with a second forward view.⁴⁶

Most recently, Tang et al⁴⁴ reported the results of the largest and only multicenter randomized trial comparing a second forward-view examination with standard colonoscopy. In this study, a second forward-view examination of the right-sided colon resulted in a 5.5% increase in right-sided colon ADR compared with the standard withdrawal colonoscopy group. However, the overall entire colon ADR was not significantly different between the 2 groups. It should also be noted that both the median total colon withdrawal time and median total right-sided colon withdrawal time were 1.5 minutes longer in the second forward-view group.

Retroflexion in the cecum is a technique that has been studied to improve the ADR by enhancing the visibility of the proximal side of the haustral folds and hepatic flexure.⁴⁷ A meta-analysis of 8 studies (3660 colonoscopies)

comparing second-look retroflexion in the right-sided colon with standard colonoscopy concluded that proximal colon retroflexion significantly increased the detection of adenomas in the right-sided colon; second-look retroflexion detected 17% of right-sided adenomas that would have otherwise been missed on standard (single-pass through) colonoscopy. The overall success rate of retroflexion was 91.9% and the rate of adverse events was .03%.⁴⁷ A more recent meta-analysis similarly found that retroflexion in the right-sided colon increased the right-sided ADR by 6% compared with standard colonoscopy.⁴⁶ Several subsequent studies evaluating the yield, maneuver success, and rate of adverse events with right-sided colon retroflexion have supported this technique with higher rates of success and low rates of adverse events.^{41,48-50}

However, retroflexion in the cecum is not always successful and can be associated with an increased risk of adverse events, such as risk of colonic perforation.⁵¹ The important practical question is comparing retroflexion in the right-sided colon with a second forward look. Insufficient data compare second forward view with retroflexion in the right-sided colon. Harrison et al⁵² were the first study to evaluate the impact of right-sided colon retroflexion compared with a second forward view on adenoma miss rates in a randomized clinical trial. The authors did not find a difference between right-sided colon retroflexion and second forward-view colonoscopy. Results of a pooled analysis of 2988 patients who underwent a second-look examination in the right-sided colon after standard colonoscopy showed no statistically significant difference in terms of the adenoma miss rate of a standard colonoscopy after second forward-view examination compared with retroflexion in the right-sided colon.⁴⁶ Similarly, in a recent multicenter randomized controlled trial, although a second look in the right-sided colon increased the ADR by 11% compared with standard colonoscopy in fecal immunochemical test–positive patients, a significant difference was not found between the second forward view and retroflexion groups (12% vs 9%, $P = .28$).⁵³ Both techniques resulted in an average additional procedure time of 1.6 minutes for second visualization.

Regardless of the technique, repeat examination of the right-sided colon appears to improve detection of right-sided lesions compared with standard colonoscopy. In a meta-analysis of 5 studies that performed a second examination of the right-sided colon immediately after the initial examination, the ADR was 28.8% in the combined examinations compared with 24.1% in the single-examination group ($P < .001$).⁵⁴ The proportion of the number of adenomas detected on the second examination ranged from 5% to 24%. Likewise, a right-sided sessile serrated lesion rate of 11.1% at the second examination has been demonstrated.⁵³

- Summary: Second look, either retroflexion in the cecum or a second forward look in the proximal colon,

increases ADR by up to 10 percentage points and right-sided adenoma detection by 5 percentage points.

Does any change in patient position during withdrawal compared with not changing patient position during withdrawal increase adenoma detection?

Patient position change during withdrawal has been evaluated as a method to increase ADR by enhancing luminal distension.^{55,56,61} A systematic review of 5 randomized controlled trials including 2210 patients concluded that total ADR was significantly increased with dynamic position change compared with a static position (odds ratio [OR], 1.34; 95% CI, 1.13-1.59); however, it should be noted that only 1 of the 5 studies included in the pooled analysis was a positive study.⁵⁶ That randomized parallel-group trial included 1072 patients and found the ADR was significantly higher in the position change group compared with the control group (42.4% vs 33.0%). Patients were in the left lateral position for a right-sided colon examination, supine position for a transverse colon examination, and right lateral position during withdrawal in the left colon.⁵⁶ Two of the included studies collected data on withdrawal time and reported that position change increased the withdrawal time by .47 minutes longer compared with static position, but the increase was not statistically different and the quality of evidence was rated as low.^{56,59,60}

Another systematic review with 6 randomized trials and 2860 patients demonstrated that dynamic position change improved the ADR (41.6% vs 34.4%; OR, 1.16; 95% CI, 1.15-1.61) without a change in mean withdrawal time.⁶¹ In another randomized crossover trial of 30 patients, East et al⁵⁵ reported an absolute increase in the number of patients with 1 or more adenomas of 11% with dynamic position changes, attributed to improved colon distention with position changes. It should be noted that the studies were done with minimal sedation, and dynamic position changes may not be practical or feasible in the United States with monitored anesthesia care and deep sedation and in patients with high body mass indices. The goal of position change is to achieve adequate distention, which may be possible even without position changes.

- Summary: Dynamic changes in patient position increase the ADR by up to 7 percentage points.

Technology

Do distal attachment devices compared with standard colonoscopy improve adenoma detection?

Distal attachment devices such as transparent ENDOCUFF, EndoRing (STERIS Inc, Dublin, Ireland), and EndoCap are designed to increase mucosal visualization and improve adenoma detection. These devices attach to the tip of the colonoscope and are used to flatten colonic folds and optimize mucosal exposure on withdrawal. Studies investigating the effect of the use of these individ-

ual devices compared with standard colonoscopy on ADR have yielded divergent results.

The use of EndoRing did not show a statistically significant increase in the ADR but was associated with a longer insertion time and a shorter withdrawal time,⁵⁷ whereas cap-assisted colonoscopy with EndoCap was found to increase the proximal colon ADR by 6% as well as the detection of flat or serrated lesions (OR, 1.33; 95% CI, 1.01-1.74).⁶² ENDOCUFF has been shown in numerous studies to increase the ADR, although the extent of improvement ranges from modest to large.^{58,63,64} A network meta-analysis demonstrated that distal attachment devices do increase ADR compared with standard colonoscopy with absolute increases in the ADR to 11.3% for low-performing endoscopists (defined as baseline ADR <10%) and to 45.2% for high-performing endoscopists (defined as baseline ADR >40%).⁶⁵ A recent meta-analysis comparing outcomes of a second-generation ENDOCUFF with standard colonoscopy also showed a significant improvement in the ADR (49.8% vs 45.6%, respectively; relative risk [RR], 1.12; $P = .02$) with a larger improvement in the ADR (9.4%, $P = .3$) among endoscopists with ADRs <30%.⁶⁶ Distal attachment devices increase the ADR for both low-performing and high-performing endoscopists but in varying degrees.

- Summary: Distal attachment devices increase the ADR by 5 to 11 percentage points.

Do enhanced imaging technologies improve adenoma detection compared with standard white-light colonoscopy?

Given the appreciable miss rate of adenomas during colonoscopy, enhanced imaging technologies emerged to augment the optical detection of neoplastic lesions during the inspection of the colonic mucosa. Narrow-band imaging (NBI) improves the visibility of vascular structures of colon polyps by using optical interference filters to spectrally narrow the bandwidths used in conventional white light, resulting in more visual detail of the superficial mucosal structures and capillaries seen in neoplastic tissue.^{67,68}

Several early meta-analyses did not show NBI to improve the ADR compared with white-light colonoscopy.⁶⁹⁻⁷¹ One meta-analysis did not show any benefit of NBI when compared with high-definition white-light colonoscopy but suggested that it may improve the ADR when compared with standard white-light colonoscopy.⁷² However, with the newer-generation colonoscopies (190 series), NBI does improve adenoma detection, particularly when the preparation is excellent. A randomized trial of tandem colonoscopy using 190 series NBI reported⁷³ a statistically significant improvement in adenoma and polyp detection with 190 series NBI versus high-definition white-light colonoscopy (adenoma, 48.3% vs 34.4% [$P = .01$]; polyps, 61.1% vs 48.3% [$P = .02$]). Atkinson et al⁷⁴ conducted a patient-level systematic review of 11 trials comprising 4491 patients and reported that NBI outperformed white-light

colonoscopy only when bowel preparation was best (OR, 1.30; 95% CI, 1.04-1.62; $P = .02$) and that second-generation bright NBI had a better ADR than white-light colonoscopy (second-generation NBI OR, 1.28; 95% CI, 1.05-1.56; $P = .02$).

Another technique of image-enhanced endoscopy is i-SCAN, a method that uses postprocessing computer algorithms to enhance the visibility of surface structures and vascular patterns with 3 adjustable modes: surface enhancement, contrast enhancement, and tone enhancement.⁷⁵ Similar to NBI, i-SCAN has not been demonstrated to improve the ADR compared with white-light colonoscopy.⁷⁶ One study reported that i-SCAN in conjunction with high-definition white-light colonoscopy may improve the ADR compared with standard white-light colonoscopy alone.⁷⁷

New-generation image-enhanced endoscopy technologies, including blue-laser imaging and linked-color imaging, have shown promising results in improving the detection of adenomas and flat polyps.⁷⁸⁻⁸⁰ Chromoendoscopy, using methylene blue or indigo carmine dye, also improves detection of adenomas. In a subgroup analysis of a large systematic review with 9 studies of chromoendoscopy, the pooled estimates of relative risk of adenoma in those using indigo carmine (7 studies, 2388 patients) in non-ulcerative colitis patients was 1.33 (95% CI, 1.20-1.48).⁷⁶

Finally, a recent innovation is a pH- and time-dependent peroral methylene blue formulation (Methylene Blue-MMX [MB-MMX]) that can be delivered directly to the colorectal mucosa and mimics the effect of methylene dye-assisted chromoendoscopy. In a trial with 1205 subjects, Repici et al⁸¹ reported that the ADR was statistically higher for the MB-MMX group (56.3% vs 47.8% for placebo). Further trials and approval in the United States are awaited.

- Summary: Enhanced imaging technologies increase the ADR by 5 to 18 percentage points.

Does CADe and artificial intelligence technologies improve adenoma detection compared with standard colonoscopy?

Application of CADe and artificial intelligence holds tremendous potential in colonoscopy for detecting polyps, adenomas, and sessile serrated lesions. Recent studies demonstrate that these technologies improve the ADR by 10% to 15%.⁸²⁻⁸⁹ In a randomized trial of 1058 individuals, artificial intelligence-assisted colonoscopy increased the ADR (29.1% vs 20.3%, $P < .001$) and adenomas detected per colonoscopy (.53 vs .31, $P < .001$) compared with standard colonoscopy.⁹⁰ The same group reported significantly lower adenoma miss rates with CADe (13% vs 40%) on tandem colonoscopy in a study with 269 individuals. Artificial intelligence technology improves ADR not just for low performers but also for high performers, as demonstrated in a prospective trial of expert endoscopists.⁹¹ The ADR was 40.4% in the control group and increased to 54.8% with artificial intelligence. Repici

et al performed a systematic review of 5 randomized trials with 4354 patients and reported a significantly higher pooled ADR (36.6% vs 25.2%, $P < .001$) and adenomas per colonoscopy (.58 vs .36, $P < .001$) with CADe than with the control group.⁸⁵ This systematic review found no significant difference between the groups in withdrawal time (417 ± 101 seconds for the CADe group vs 435 ± 149 for the control group, $P = .1$).

Although most studies focused on the improved detection of polyps and adenomas, other applications include polyp size determination, real-time polyp histology determination, preparation quality rating, adequacy of mucosal inspection, and verification of cecal landmarks. It should be noted that the increased ADR reported in most studies was because of the increased detection of diminutive adenomas.⁹² It is also not known if the benefits of artificial intelligence are sustained over time, and if it can be a training tool wherein the endoscopists can sustain the improved detection without the artificial intelligence. Nevertheless, it remains an exciting and important intervention that is likely to be integrated into standard colonoscopy in the near future.

- Summary: CADe technologies increase the ADR by up to 10 percentage points.

Interventions (facility level, provider level)

Does split-dose bowel preparation before colonoscopy compared with day-before bowel preparation increase adenoma detection? Although adequate bowel preparation is a basic requirement for the detection of colorectal cancer and polyps, inadequate bowel preparation is reported in up to 25% of colonoscopies.⁹³ Therefore, use of a split-dose bowel preparation, where approximately half of the purgative is given on the day of colonoscopy, is strongly recommended by the U.S. Multi-Society Task Force on Colorectal Cancer⁹³ because split dosing is associated with higher quality bowel cleansing than day-before preparations.^{94,95} A meta-analysis of 4 trials comparing split-dose with day-before bowel preparations in 1258 participants found that split dosing was associated with a significantly increased ADR (RR, 1.26; 95% CI, 1.22-1.92).⁹⁶ Moreover, split-dose bowel preparation was also associated with an increased AADR (RR, 1.53; 95% CI, 1.22-1.92; 3 trials and 1155 participants) and increased sessile serrated polyp detection (RR, 2.48; 95% CI, 1.21-5.09; 2 trials and 1045 participants).⁹⁶ It is notable that the effect of split dosing on sessile serrated polyp detection may be greater than for adenomas and advanced adenomas. Therefore, based on the superior neoplasia detection and greater patient acceptance,⁹⁷ split-dose bowel preparation should be routinely used instead of day-before preparation.

- Summary: Split-dose bowel preparation increases the ADR by up to 26 percentage points compared with day-before preparation.

Does same-day bowel preparation before colonoscopy compared with split-dose bowel preparation increase adenoma detection?

Given the finding that the quality of bowel preparation varies inversely with the duration of the interval between the last dose of purgative administration and the start of the colonoscopy,⁹⁸ same-day bowel preparation has been recommended by the U.S. Multi-Society Task Force as an acceptable alternative to split dosing, especially for patients undergoing an afternoon colonoscopy.⁹³ Same-day bowel preparation has been demonstrated to result in superior bowel cleansing compared with day-before preparation,^{99,100} although data are limited on its impact on adenoma detection.¹⁰¹ Eight studies including 1587 participants were pooled in a meta-analysis comparing split-dose with same-day bowel preparation, demonstrating no statistical evidence of superiority of split dosing (RR, 1.02; 95% CI, .89-1.17).⁹⁶ Thus, same-day bowel preparation does not increase the ADR compared with a split-dose bowel preparation. However, these studies support the U.S. Multi-Society Task Force's strong recommendation of administering at least a portion of the purgative on the day of the procedure to optimize detection of neoplasia.⁹³

- Summary: There is no difference in the ADR with the use of a same-day bowel preparation compared with a split-dose bowel preparation.

Does being observed and/or recorded compared with not being observed and/or recorded increase adenoma detection?

The Hawthorne effect, whereby individuals modify their behavior in response to being observed, could be leveraged to improve adenoma detection in colonoscopists who know how to perform effective examinations but may not use their best technique when not being observed.¹⁰² One pilot study video recorded routine colonoscopies by 7 colonoscopists, with and without their awareness, and demonstrated that mean inspection time increased by 49% after disclosure of a video recording.¹⁰³ In a time-series study of 421 patients undergoing screening colonoscopy in an academic outpatient endoscopy facility, introduction of video recordings was associated with a significant increase in hyperplastic polyp detection (from 34.6% to 44.1%, $P = .046$), although the ADR was nonsignificantly increased (from 33.7% to 38.5%, $P = .31$).¹⁰⁴ Among the 6 endoscopists, only 1 had a significant increase in ADR from 22.6% to 57.7% ($P < .01$). This relatively small sample size was underpowered to detect a 5% increase in adenoma detection, which would be clinically significant. Moreover, the baseline ADR was quite good for the group as a whole, potentially limiting the impact of the intervention. However, the significant impact on ADR for a low-performing colonoscopist suggests that video recording may have value for this subset of endoscopists. Furthermore, evaluation of video recordings can offer opportunities for feedback that may lead to improved performance.^{37,105}

- Summary: Video recording alone is not associated with improvement in ADR.

Does the involvement of a second observer examining the colon for colon polyps compared with the endoscopist alone increase adenoma detection?

The presence of an experienced nurse in the procedure room is associated with decreased immediate adverse events, reduced procedure times, increased cecal intubation rates, and increased polyp detection.^{106,107} Another retrospective study found that the presence of a second observer (ie, a gastroenterology fellow) during withdrawal was associated with increased adenoma detection.¹⁰⁸ Therefore, randomized controlled trials have been undertaken to evaluate the impact of observation of withdrawal by an endoscopy nurse on adenoma detection.¹⁰⁹⁻¹¹² A meta-analysis of these trials including 2268 patients demonstrated that assignment of nurses to observe the colonic inspection was associated with significantly increased adenoma detection (RR, 1.19; 95% CI, 1.07-1.32) and nonsignificantly increased advanced lesion detection (RR, 1.33; 95% CI, .95-1.87).¹¹³ These studies suggest that colonoscopists should not only endeavor to retain experienced endoscopy nurses, but they should also encourage endoscopy room staff to participate in the inspection of the colonic mucosa whenever not otherwise occupied with their role in monitoring of the patient and assisting with the procedure.

- Summary: A second observer examining the colon is associated with improvement in the ADR by up to 19 percentage points.

Endoscopist education and feedback

Feedback is an essential element of instruction and education for learners and provides valuable information to learners to help them improve their overall performance. It is widely believed that feedback plays a pivotal role in successful learning. Furthermore, feedback is critical for improving not only knowledge acquisition but learner motivation and satisfaction.^{114,115} Consequently, it is important to understand the role and impact of feedback in improving quality in endoscopy and how it may be embedded and supported in endoscopy unit quality improvement programs.

Do physician report cards compared with no report cards increase adenoma detection?

A report card is a tool that communicates a learner's performance on an activity at a regular cadence. It provides information on performance, reports benchmarks or targets, and may even have additional comments to help enhance a learner's performance on an activity. Across several areas of health care, notably in surgery, auditing, benchmarking, and sharing data improve procedural performance.¹¹⁶⁻¹¹⁸ A recent meta-analysis by Bishay et al¹¹⁹ shed some light in this area with respect to endoscopy quality indicators and report cards. Their extensive analysis on report cards and ADRs included 12 studies (11 of which were

observational studies) with over 33,000 colonoscopies performed by 154 endoscopists. Although heterogeneity was present in the included studies with respect to the modality of feedback provided, 7 studies directly used report cards to share individual endoscopist performance, whereas the remaining studies used written or verbal feedback to endoscopists on their performance. A significant improvement in the ADR after the feedback period compared with the no-feedback time interval was observed (RR, 1.21; 95% CI, 1.09-1.34). More importantly, feedback in the form of report cards significantly improved the ADR for endoscopists who had a baseline ADR under 30% (RR, 1.27; 95% CI, 1.01-1.60) and for those whose baseline ADR was in the lowest (RR, 1.62; 95% CI, 1.18-2.23) and middle (RR, 1.19; 95% CI, 1.11-1.29) 3 quintiles. Although the largest benefit of improving ADR from report cards appeared to be from a single episode of feedback, recurrent feedback was also associated with a statistically significant benefit. Many reasons explain the positive results noted with ADR and report cards, including the Hawthorne effect, and more randomized control studies are required to assess what type of data should be included in report cards, optimal modalities of sharing report cards, and the frequency of sharing such information with endoscopists. Thus, providing feedback to endoscopists on their endoscopy performance leads to improvement in several colonoscopy quality indicators; in particular, the ADR improves with feedback in the form of report cards especially among endoscopists who are performing below established benchmarks. Such an intervention is helpful and should be included in an endoscopy unit's quality improvement program.

- Summary: Physician report cards are associated with improved ADR by 10 to 19 percentage points

Do focused educational interventions compared with standard education increase adenoma detection? Focused, module, and competency-based educational interventions play an important role in improving ADRs. First, structured training programs for endoscopists lead to improved performance across several colonoscopy quality indicators such as cecal intubation and ADRs.¹²⁰ Second, 2 large meta-analyses have shown that educational interventions led to improved ADRs.^{119,120} One large meta-analysis of 8 studies from 2013 to 2017 including 115 endoscopists illustrated that training interventions improve ADR, AADR, and adenocarcinoma detection rates.¹¹⁹ Training across these included studies spanned a plethora of modalities ranging from didactic lectures, hands-on training, and proctoring; in-person training constituted most educational modalities used. Training compared with no training demonstrated a solid trend toward increased ADRs (OR, 1.16; 95% CI, 1.00-1.34).¹²¹ Another meta-analysis again included 8 studies from 2010 to 2019 with nearly 90,000 colonoscopies performed.¹²⁰ There was a 29% relative increase in ADRs (RR, 1.29; 95%

CI, 1.22-1.37) among those endoscopists who underwent some form of educational instruction on colonoscopy; furthermore, educational interventions were associated with a 39% relative increase in proximal adenoma detection rates.¹²²

Third, many studies addressing educational interventions vary in several areas such as duration, content covered, assessment tools, and modalities and frequency of feedback. Little information is available on which training modalities may be superior in terms of improving ADR. One of the best-known models is the Endoscopic Quality Improvement Program training, which is composed of didactic presentations focusing on high-quality endoscopy techniques (eg, optimal withdrawal techniques) and image recognition and classification methods of neoplastic versus non-neoplastic polyps. Implementation and adoption of the Endoscopic Quality Improvement Program in endoscopy units is associated with a 28% to 73% increase in ADRs.¹²³ Interestingly, hands-on training and didactic interventions appear to improve the ADR at approximately the same rate.¹²² Such training modules may be locally developed or accessed through programs developed by professional societies, such as those available through ASGE's learning portal or GI LEAP online. Consequently, as a whole, educational interventions have a relatively modest improvement on endoscopists' ADRs, but more research is warranted to elucidate which training modalities and timing of training may be optimal to enhance an endoscopist's ADR.

- Summary: Focused educational interventions improve ADR by 20 to 26 percentage points.

Do financial incentives compared with no financial incentives increase adenoma detection? Although financial incentives can increase colon cancer screening rates among patients,^{124,125} it remains unclear if financial incentives can improve colonoscopy quality indicators such as the ADR. Minimal data are available examining the association of financial incentives and endoscopy performance improvement measures. Financial bonuses targeted for endoscopists lead to an increased use of CRC tests, but only to a small degree of about 3%.¹²⁶ To date, only 1 survey study of 117 endoscopists across 4 healthcare systems found no association between ADR and self-reported financial motivations.¹²⁷ Currently, there are ongoing discussions on shifting from volume to quality and value in payment reform and reimbursements for endoscopists.¹²⁸ However, it remains to be seen if such a shift improves overall performance and, in particular, ADRs. Future studies are needed to determine if such a changing reimbursement paradigm results in increased ADRs for endoscopists participating in such programs.

- Summary: Financial incentives are not associated with an improvement in ADR.

Does public reporting compared with no public reporting increase adenoma detection?.

Public reporting is a strategy to address quality and cost in a healthcare system by providing consumers, payers, and other healthcare providers with information about the performance of specific providers on services or procedures they provide. Transparency in reporting quality indicators has been advocated and has gained momentum in multiple areas of health care.¹²⁹⁻¹³¹ In gastroenterology, although there are several mechanisms by which data on endoscopy quality indicators are reported, there is a paucity of research examining the impact of this public reporting of data and improvement in endoscopist performance. A single study in Peoria, Illinois of 11 gastroenterologists at a private endoscopy practice illustrated that public reporting on colonoscopy quality indicators was associated with a 45% increase in the ADR and a 25% increase in the AADR.¹³² Several reasons were proposed for the profound increases in these 2 measures: selection pathway (eg, patients will use this information to select their provider), change pathway (eg, transparency of one's data motivates a provider to change), and reputation. Although these data are promising and encouraging, more research is needed to validate these findings. Critical to the success of public reporting for endoscopy quality indicators is to ensure the data are accurate and easily accessible and that individuals viewing the information understand how the data are meaningful.

- Summary: Public reporting improves the ADR by up to 25 percentage points.

CONCLUSION

Monitoring and reporting ADRs are the cornerstones of establishing a quality colonoscopy program. The goals of a high-quality colonoscopy program are not just to meet the minimum ADR benchmarks but to aim for aspirational targets of 50% or higher. We encourage all endoscopists to try 1 or more interventions to improve their ADR. There are many different approaches to improving ADR ranging from added and enhanced inspection techniques to distal attachment devices, systematic interventions, and educational feedback. Most interventions can be expected to improve the absolute ADR by 8% to 10%. The choice of 1 or more interventions depends on time, effort, and resources available. A good strategy might be to begin with low-cost and low-effort interventions such as WE or changing patient position and escalate as desired. Strong techniques, such as optimizing withdrawal technique, using WE, and routine second look in the right-sided colon are attractive first steps, because they are low cost and can be targeted to individual endoscopists. At the practice level, implementing split-dose or same-day preparation is likely to improve the ADR for all endoscopists. Distal attachment devices and other technology can enhance

and improve the ADR but are not a surrogate for good technique and do modestly increase the cost per procedure. Systematic interventions can benefit larger groups and result in sustained improvements but require more cost and effort. Improvements in the ADR and its long-term impact on the effectiveness of colonoscopy are important areas of future research.

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Abbreviations: AADR, advanced adenoma detection rate; ADR, adenoma detection rate; ASGE, American Society for Gastrointestinal Endoscopy; CADe, computer-aided detection; CI, confidence interval; CRC, colorectal cancer; NBI, narrow-band imaging; OR, odds ratio; RR, relative risk; WE, water exchange; WI, water immersion.

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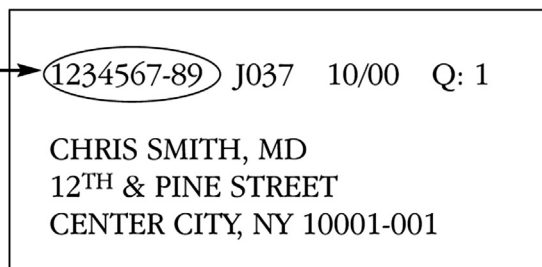
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