Review Article

A review of quality metrics in colonoscopy

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Abstract: Colonoscopy is a commonly performed procedure with increasing use across medical specialties including gastroenterology, general surgery, colorectal surgery, and primary care. Over the past several decades, studies have demonstrated variation in colonoscopy quality with regard to adenoma detection rate and missed colorectal cancers among endoscopists within the same specialty and more significantly, across specialties. There is mixed literature suggesting that gastroenterologists may have better adenoma detection rates and colonoscopy completion rates than other specialists including surgeons, possibly related to practice volume and training. In an effort to standardize colonoscopy and improve overall outcomes, the American Society for Gastrointestinal Endoscopy and the American College of Gastroenterology Task Force on Quality in Endoscopy (ASGE/ACG) published a list of pre-, intra-, and post-procedure quality metrics in colonoscopy with associated performance targets. Surgeon endoscopists should be prepared to evaluate their performance based on these quality metrics. There is ongoing investigation into various new possible performance metrics in an effort to define exactly which metrics best correlate with clinical outcomes. In addition, the method to most accurately and efficiently document colonoscopy performance metrics and outcomes is not standardized, but the use of video recording especially in the era of the electronic medical record may be of value.

Keywords: Colonoscopy; endoscopy; quality metrics; performance metrics; surgeon endoscopist

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Introduction

Colonoscopy is the most commonly performed endoscopic procedure in the United States, with millions of lower endoscopies performed each year (1). Colonoscopies are performed by endoscopists from many different medical specialties including gastroenterology, general surgery, colorectal surgery, internal medicine, and family medicine. Despite the common use of colonoscopy, multiple studies have demonstrated variation in the quality of colonoscopies both among endoscopists within the same specialty as well as across specialties. This may be related to the endoscopist's training, volume, and practice setting (2-6).

In light of these findings, in 2006, the American Society for Gastrointestinal Endoscopy and the American College of Gastroenterology Task Force on Quality in Endoscopy (ASGE/ACG) published guidelines for pre-procedure, intra-procedure, and post-procedure quality metrics for colonoscopy, with each metric graded on the strength of evidence supporting it (7). The goal of these guidelines was to define competency in colonoscopy, standardize the procedure, and target areas for quality improvement among endoscopists. An update was subsequently published in 2015 that also set targets for performance for each metric (8). These metrics and target compliance rates are summarized in *Table 1*. By measuring the outlined quality metrics and

Table 1 Summary of ASGE/ACG quality metrics and recommended performance targets

Timing related to procedure	Quality metric	Performance target
Pre-procedure	Informed consent obtained and fully documented	>98%
	Screening and post-polypectomy/post-surgical resection colonoscopy performed at appropriate intervals	≥90%
	Screening colonoscopy in inflammatory bowel disease performed at appropriate intervals	≥90%
	Colonoscopy is performed for an appropriate indication; indication is documented	>80%
Intra-procedure	(I) Bowel preparation adequate to allow for use of recommended surveillance/screening guidelines; (II) Procedure note documents quality of bowel preparation	(I) ≥85%; (II) >98%
	Biopsies obtained when colonoscopy is for chronic diarrhea	>98%
	Recommended biopsies obtained in surveillance of inflammatory bowel disease	≥98%
	Endoscopic removal of pedunculated polyps or sessile polyps <2 cm attempted before surgical referral	>98%
	Adenoma detection rate in average-risk patients	Men: ≥30%; women: ≥20%; all: ≥25%
	(I) Average withdrawal time in negative colonoscopy; (II) documentation of withdrawal time	(I) ≥6 minutes average; (II) >98%
Post-procedure	Incidence of: (I) perforation; (II) post-polypectomy bleeding	(I) all exams: <1/500; screening: <1/1,000; (II) <1%
	Post-polypectomy bleeding managed without surgery	≥90%
	Appropriate interval for repeat colonoscopy is documented and provided to patient	≥90%

ASGE/ACG, the American Society for Gastrointestinal Endoscopy and the American College of Gastroenterology Task Force on Quality in Endoscopy.

striving to achieve the proposed benchmarks, endoscopists may be able to target areas of weakness in order to improve their outcomes and close the aforementioned performance gaps. Several of the performance metrics most closely associated with outcomes are reviewed here.

Pre-procedure metrics

Indication for colonoscopy

The indication for colonoscopy should be documented routinely. The goal is to reduce inappropriate or unnecessary colonoscopies in order to minimize risk to the patient and maximize cost-effectiveness. Every colonoscopy should be based on the individual patient's history of prior colonoscopies and be indicated based on screening and surveillance guidelines (9). A list of appropriate indications for colonoscopy is available from the ASGE (https://doi.org/10.1016/j.gie.2012.01.011), and when a colonoscopy is performed outside of standard indications, the reason should be well documented.

Appropriate screening and surveillance intervals

Although there is ample literature to support current screening and surveillance guidelines, several surveys have demonstrated that endoscopists frequently recommend repeat colonoscopy at intervals shorter than what is recommended by the guidelines and that surgeons may repeat colonoscopies at shorter intervals than gastroenterologists (10-12). In order to minimize procedural risks and maximize cost-effectiveness, adherence to appropriate screening, post-polypectomy, and post-cancer resection surveillance intervals as well as screening intervals in inflammatory bowel disease (IBD) is important.

Recommended screening intervals are as follows:

- The recommended interval for colonoscopy after a negative exam (no adenomas) in an average-risk patient ≥50 years old with an adequate bowel

preparation is 10 years;
- ❖ After polypectomy of 1–2 small tubular adenomas, the recommended interval is 5 years;
- ❖ After polypectomy of three or more small adenomas or any advanced adenoma (large, villous, high-grade dysplasia), the exam should be repeated at 3 years;
- ❖ After piecemeal resection of a sessile adenoma >2 cm, the colonoscopy should be repeated at 3 months, 6 months, and 1 year;
- ❖ Colonoscopy should be performed at 1 year after a resection for colorectal cancer.

The recommended screening intervals in IBD are less clear cut, but given the increased risk of colorectal cancer in this population, screening colonoscopy is recommended at shorter intervals than the general population. There are no randomized controlled studies to demonstrate the benefit of surveillance in IBD, however, small case-control studies support this recommendation. A Swedish case control study compared 40 patients with ulcerative colitis (UC) who died of colorectal cancer to 102 patients with a diagnosis of UC alone matched for age, sex, and extent and duration of the disease. Although the results were not statistically significant given the small study size, this study found a survival benefit in patients who had one surveillance colonoscopy at any time after the diagnosis of UC [relative risk (RR) 0.29], and a stronger survival benefit in patients who had two surveillance colonoscopies after diagnosis of UC (RR 0.22) (13).

Currently, it is recommended that screening colonoscopies are initiated 7–10 years after onset of disease (defined as onset of symptoms in patients with UC with disease extending beyond the rectum, and patients with Crohn's disease involving more than one third of the colon). Because IBD is often diagnosed in adolescence or young adulthood, screening in these patients often will begin before age 50. Surveillance colonoscopy should be repeated every 2–3 years in patients without primary sclerosing cholangitis (PSC) or severe colon scarring between 7 and 20 years of disease. However, patients with PSC, marked colon changes, or long duration of disease may require shorter screening intervals.

Intra-procedure metrics

Intra-procedure metrics are markers for the quality of the colonoscopy itself, which is important in the effectiveness of the colonoscopy (i.e., identification of precancerous lesions in screening colonoscopy) as well as reducing the need for repeat colonoscopy.

Bowel preparation

In order to minimize the need for repeat colonoscopy and maximize the quality of the exam, the bowel preparation should be complete enough that the patient does not need to be brought back for a repeat exam within 1 year due to inadequate bowel preparation. If this is not achieved, bowel preparation protocols should be re-evaluated, including patient education, choice of purgative, and protocol for administration. Special consideration and more aggressive regimens should be given to patients at high risk for inadequate preparation, namely those with a history of constipation, opioid use, a history of poor bowel preparation at prior colonoscopies, or those with diabetes.

Quality of bowel preparation has been found to be significantly associated with increased adenoma detection rate (ADR). In a randomized prospective study of 107 colonoscopies evaluating the efficacy of two commonly used bowel regimens, ADRs were significantly higher with the regimen that yielded more preparations rated as "excellent" (14). Additionally, a prospective multi-center study from the European Panel of Appropriateness of Gastrointestinal Endoscopy examined the effect of bowel preparation on polyp detection rate (PDR) and found higher PDRs in high quality cleansing and intermediate quality cleaning compared to low quality cleansing [odds ratio (OR) 1.46 and 1.73, respectively] (15).

The quality of the bowel preparation should always be documented. Although multiple scales are available, there is no consensus on rating the quality of bowel preparation. *Table 2* summarizes the three most commonly used validated bowel preparation rating scales (Aronchick, Boston Bowel Preparation, and Ottawa Bowel Preparation scales). Many providers use the terms "excellent", "good", "fair", and "poor" and some use "adequate" versus "inadequate". There are no standardized definitions for any of these terms, but the Task Force recommends classifying the preparation as "adequate" if it allows for detection of adenomas >5 mm in size.

Intubation of the cecum

In order for a colonoscopy to be considered "complete", the cecum should be intubated, defined as passage of the endoscope proximal to the ileocecal valve. Proof of intubation is provided by taking still photos of the anatomic landmarks (appendiceal orifice and ileocecal valve). Complete colonoscopy is important because of the

Table 2 Characteristics of three commonly used bowel preparation scales

Scale name	Scores whole colon versus colon by segment (left, transverse, and right)	Scores before versus after cleansing	Scoring system (best prep. to worst prep.)	Scale range
Modified Aronchick Scale	Whole colon	Before	Excellent: small amount of clear liquid, >95% mucosa seen	Poor to excellent
			Good: small amount of turbid fluid, >90% mucosa seen	
			Fair/adequate: moderate amount of stool that can be cleared with suctioning, >90% mucosa seen	
			Inadequate: exam completed but turbid fluid/feces present, <90% mucosa seen	
			Poor: exam not completed due to large amount of feces, re-prep required	
Boston Bowel Preparation Scale	Colon by segment	After	3: entire mucosa seen well with no residual staining	0 (worst) to 9 (best)
			2: minor amount of residual staining, mucosa seen well	
			1: only portions of mucosa seen due to staining from residual stool and/or opaque liquid	
			0: mucosa not seen due to solid stool that cannot be cleared	
Ottawa Bowel Preparation Quality Scale	Colon by segment + whole colon:	Before		0 (best) to 14 (worst)
	Segmental scores		0: empty colon, no liquid	
			1: minimal liquid, no suctioning required	
			2: suctioning required to see mucosa	
			3: washing and suctioning required to see mucosa	
			4: solid feces, not washable	
	Whole colon		0–2: overall quantity of fluid	

prep., preparation.

significant number of proximal lesions and higher mortality associated with proximal colon cancers, and complete colonoscopy is associated with a lower rate of missed or interval colon cancers (16). In a retrospective study of over 14,000 patients diagnosed with colon cancer within 3 years of colonoscopy, patients of endoscopists with a >95% completion rate compared with those with a completion rate of <80% were significantly less likely to develop both distal and proximal post-colonoscopy colorectal cancers (distal: OR 0.73; proximal: OR 0.72) (17). This may be explained by the increased ADR in endoscopies with cecal intubation as ADR is the metric with the strongest association with development of post-colonoscopy colorectal cancer (18).

ADR

ADR is a value unique to each endoscopist and is defined as the number of patients with ≥1 adenoma removed divided by the total number of patients ≥50 years old undergoing screening colonoscopy. It is the quality metric with the strongest association to the development of interval colorectal cancer. A large retrospective review of 269,972 screening colonoscopies demonstrated that the frequency of interval or "missed" colorectal cancer increases dramatically with an ADR <20%, and that for every 1% increase in ADR there is a 3% decrease in interval colorectal cancer and a 5% decrease in the risk of a fatal interval colon cancer (19). It is clear that endoscopists that remove more adenomas and therefore have a higher ADR clear more pre-cancerous lesions and prevent more colorectal cancers than endoscopists with low ADRs. The Task Force has set the benchmark for ADR at 25% overall, 30% in males, and 20% in females. These targets have increased since the original ASGE recommendation of a target of 25% ADR in

males and 15% in women in 2006 (7) as more recent studies have shown that higher ADRs are possible (20).

Withdrawal time

Target scope withdrawal time (cecum to anus) should average >6 minutes in average-risk patients with an intact colon. Longer withdrawal times have been shown to be associated with an increase in ADR. When reviewing 2,053 screening colonoscopies performed by 12 community gastroenterologists, withdrawal times of >6 minutes significantly increased both the ADR and the detection of more advanced lesions relative to withdrawal time <6 minutes (21). Increasing withdrawal time is a strategy to increase ADR as it generally implies a more thorough examination of the colonic mucosa. A caveat to recommending longer withdrawal times for endoscopists who already have a high ADR is that longer withdrawal times may not necessarily further improve their individual ADR. For endoscopists with ADRs below the recommended target, however, increasing withdrawal time is a valuable measure for performance improvement.

Endoscopic polypectomy

Endoscopic resection of pedunculated polyps and sessile polyps <2 cm should be attempted prior to surgical referral since endoscopic resection is less invasive, requires less time, and is more cost-effective. A cohort study of 280 patients who underwent endoscopic or surgical resection of polyps found that the case duration for surgery was 88 minutes longer than endoscopy, length of stay was 3.4 days greater, and mean cost of open surgical resection was $6,165 compared to $892 for piecemeal polypectomy which was the most expensive endoscopic therapy (22). Every colonoscopist should be comfortable performing routine polypectomy. However, for cases that are beyond the colonoscopist's comfort level, referral to a more experienced endoscopist prior to surgical referral is advised.

Post-procedure metrics

Bleeding and perforation

Bleeding and perforation are the most common complications of colonoscopy (23). Post-polypectomy bleeding is the most common complication, and the risk of bleeding is increased in patients with large polyps, proximal colon polyps, and in patients taking anticoagulation or anti-platelet medications. Post-polypectomy bleeding can be immediate or delayed, but in either case if the bleeding does not stop spontaneously, it should be managed endoscopically with holding pressure, injection of epinephrine, use of cautery, or endoscopic clips. The endoscopist should be familiar with techniques to both prevent bleeding (type of current used, epinephrine injection) and to stop bleeding when it occurs (holding pressure and use of clips, epinephrine injection, and judicious use of cautery). Surgical intervention for post-polypectomy bleeding should be considered an intervention of last resort, and every effort should be made to obtain hemostasis endoscopically prior to surgical referral.

Perforation is a less common but serious complication. A large retrospective review of 30,366 colonoscopies over 16 years reported 35 perforations yielding an incidence of 0.12%, which is similar to results from other large series. In this series, although the overall incidence of perforation was low, morbidity after perforation was 40% and mortality was 8.6% at 30 days (24). Perforation occurs due to either mechanical trauma by the endoscope tip or loop, barotrauma from over-insufflation, or therapeutic procedures such as use of electrocautery for polypectomy or bleeding. The risk of perforation, therefore, can be reduced by avoiding excessive pushing of the scope against resistance, cautious dilation of strictures, use of carbon dioxide insufflation instead of air, and use of cold resection techniques instead of electrocautery. Screening colonoscopy has less inherent risk for perforation than lower endoscopy performed for other reasons since patients are asymptomatic and fewer endoscopic interventions are required such as biopsies.

Future directions

ADR

In order to continue to improve the quality of colonoscopies, new measures and means of tracking outcomes should be investigated. One area of discussion is whether ADR is really the best performance indicator. One drawback of using ADR is that it requires manual pathology entry into the chart in order to track this outcome. To skirt this problem, it may be possible to use PDR instead of ADR because PDR does not rely on a specific pathology, and documentation of polyp removal is done at the time of endoscopy. The natural limitation to this is that PDR

includes polyps that are not pre-cancerous, and there have been no large prospective trials proving that higher PDRs are correlated with lower rates of the development of colorectal cancer.

It has also been suggested that tracking ADR may lead endoscopists to perform a less thorough exam after identification of one adenomatous-appearing polyp since ADR differentiates only between 0 versus 1 adenoma removed and more adenomas removed per patient does not increase the endoscopist's tracked ADR. It stands to reason, however, that more adenomas removed per patient leads to fewer cases of colon cancer, so a better measure of quality may be the number of adenomas removed per patient per colonoscopy. Wang *et al.* have proposed using "adenomas under the curve (AUC)" as an alternate metric. This takes into account not only ADR but also the rate at which an endoscopist detects more than one adenoma. The area under the curve is then plotted and converted into reportable units. In their study of this metric, it was found that amongst eighteen endoscopy groups working with the same patient population, ADR varied by only 10.6% while AUC varied by 25%. When these groups were broken into academic versus community groups, ADR did not vary significantly while AUC did (25). Although this requires separate labeling of each adenoma removed and sent to pathology, this may be a more meaningful quality indicator than ADR. Further studies are needed to determine the optimal metric for measuring either polyp or adenoma detection.

Video recording

When considering how to improve both the quality of colonoscopy as well as the documentation of the procedure, video-recording of the colonoscopy may be a reasonable option. In order to examine a particular endoscopist's performance with regards to meeting the above quality metrics, the colonoscopy must be thoroughly and properly documented. By capturing the actual exam on video, it ensures not only a means for complete documentation of the entire procedure but also accurate documentation. In one prospective trial, eight expert examiners were shown photographs of the cecum including the appendiceal orifice and ileocecal valve from 110 colonoscopies. They were also shown video documentation from 50 more colonoscopies and then asked to score how confident they were that the cecum had been reached and a complete colonoscopy performed. When photographs were reviewed, the scores varied greatly between examiners with lower overall confidence levels that the cecum had been reached, even when the recommended landmarks were included. However, the reviewers were consistently confident that the cecum had been reached when reviewing the video recordings (26). This suggests that video recording is of greater value than written or photo-documentation when tracking quality metrics.

As discussed above, one weakness of using ADR or PDR as a quality metric is that it may act as a subconscious incentive to perform a less thorough exam after identification of one adenoma/polyp. Video recording may encourage sustained high-quality exam even after identification of an adenoma since the colonoscopy would then be available for audit at any time after the procedure. One study of seven endoscopists compared colonoscopy quality before and after the endoscopists were made aware that their exams were being video-recorded. Overall performance, including the quality of fold examination, luminal distention, cleanup, and inspection time were all significantly improved after the endoscopists were made aware that the exams were being recorded. In fact, inspection time increased by 49%, and the overall quality of mucosal inspection increased by 31%. Although ADR was not measured directly in this study, the measured parameters are known to correlate with higher ADR (27). Another study directly examined ADR before and after video-recording among six endoscopists. Although the study was underpowered to detect a statistically significant improvement, there was improvement in ADR among each endoscopist and a 4.8% overall improvement across the entire group (28). As technology evolves, it will become easier to record colonoscopies and embed them in the electronic medical record, and this may serve as a valuable tool in measuring, monitoring, and improving performance.

Quality metrics among surgeons

Although it has been suggested by some that gastroenterologists achieve better outcomes in colonoscopy than other specialists, there is ample literature that refutes this. It has been shown that surgeons achieve equal ADR and rates of colonoscopy completion as gastroenterologists. One prospective study of over 10,000 colonoscopies performed by 14 surgeons and 15 gastroenterologists found no difference in ADR, cecal intubation, or adverse events between gastroenterologists and surgeons after multivariate analysis adjusting for patient age, sex, and indication for colonoscopy (29). Similarly, a

retrospective cohort study of 3,235 colonoscopies performed by 13 surgeons and 8 gastroenterologists found no difference in the rate of complete colonoscopy or complications between specialties (30).

The effect of case volume on colonoscopy quality and safety has also been questioned, especially since gastroenterologists tend to maintain higher annual case volumes than surgeons. In both of the two previously mentioned studies, however, just under 40% of the colonoscopies were performed by surgeons, suggesting that quality and safety still remain high even among surgeons with lower case volumes. In examining surgeon endoscopists alone, over 13,000 colonoscopies performed by surgeons were prospectively studied with no difference found in the safety of colonoscopy with increasing annual case volume, although time to completion decreased with increasing experience (31). In addition, when comparing gastroenterologists and surgeon endoscopists, several other single-institution studies have demonstrated that surgeon endoscopists can achieve the same quality and safety as gastroenterologists and meet the aforementioned quality metric targets (32,33).

Implementation of quality metrics in surgical practice

Training and maintenance of credentialing

Every endoscopist must complete formal training. Although the Accreditation Council for Graduate Medical Education (ACGME) requires a minimum of 50 colonoscopies performed in general surgery residency, as discussed previously, case volume alone does not necessarily correlate with outcomes. Given this, proficiency must be assessed by means other than meeting minimum case requirements in training. The Society of American Gastrointestinal Endoscopic Surgeons (SAGES) has published guidelines for privileging and credentialing in endoscopy which may be accessed here: https://www.sages.org/publications/guidelines/guidelines-privileging-credentialing-physicians-gastrointestinal-endoscopy.

As of 2018, the American Board of Surgery has required that all graduating residents complete the Fundamentals of Endoscopic Surgery (FES) exam, which is a validated tool to measure cognitive and hands-on endoscopy skills with higher scores correlating to better colonoscopy performance (34). Surgeons graduating before 2018 should pursue another form of formal endoscopic training ("mini-fellowships") that include cognitive skills assessment, technical skills assessment, and meet the minimum case volume for certification in endoscopy. Technical competency should be assessed using a validated tool such as the Global Assessment of Gastrointestinal Endoscopic Skills (GAGES) or the Mayo Colonoscopy Skills Assessment Tool (MCSAT).

After completion of training and initial certification, each endoscopist should undergo an initial Focused Professional Practice Evaluation (FPPE) to establish baseline skills and quality metrics. This should be followed by periodic Ongoing Professional Practice Evaluations (OPPE) which should evaluate endoscopic skills, again using a validated tool such as GAGES or MCSAT. This will allow for determination of the endoscopist's success in meeting minimum quality metric standards and can identify areas for improvement.

Practice-wide tracking of quality metrics

Each endoscopy group or unit must decide the best method to document and track quality metrics. In most practices, this will involve documentation of the colonoscopy in the electronic medical record. A pre-templated exam note that prompts the writer for documentation of each performance metric may be of particular value. This ensures quick and complete documentation of all quality metrics and allows for a discrete and easily accessible record that may be audited or tracked over time. After implementing a standardized method to record or track quality metrics, a schedule must be decided on to gather and review the data, whether that is done quarterly, bi-annually, or yearly. Consistent performance review will allow for targeting areas for improvement on individual and practice-wide levels.

Conclusions

Tracking performance metrics is an important strategy for ensuring high quality colonoscopy and for identifying areas for improvement. Currently, ADR is the metric that is most closely inversely associated with the development of colorectal cancer. Moving forward, however, new quality metrics should be investigated in order to determine and refine the best indicators for overall colonoscopy quality, especially with regards to the ability of screening colonoscopy to decrease the risk of the development of colon cancer. Additionally, the best way to record and measure these metrics is still under investigation, though with evolving technology and the electronic medical record,

digital video recording of colonoscopy and its insertion into the electronic patient chart is a likely development in the near future. Quality metrics should be tracked on both an individual and practice-wide level, and each endoscopy group should determine the best way to do this in their specific practice.

Training in endoscopy differs between surgeons and gastroenterologists with different case volumes required in order to be deemed competent (50 colonoscopies in general surgery and 140 colonoscopies in gastroenterology). Although this does not appear to contribute to a difference in outcomes between specialties, there is a dedicated effort in general surgery to continuously enhance training and improve the quality of colonoscopies performed by surgeon endoscopists. Formal training programs such as FES and mini-fellowships provide structured endoscopy training, and validated skills assessment tools such as GAGES and MCSAT allow for ongoing endoscopist assessment.

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Footnote

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