REVIEW

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Strategies to improve screening colonoscopy quality for the prevention of colorectal cancer

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The incidence and mortality of colorectal cancer (CRC) have decreased through regular screening colonoscopy, surveillance, and endoscopic treatment. However, CRC can still be diagnosed after negative colonoscopy. Such CRC is called interval CRC and accounts for 1.8–9.0% of all CRC cases. Most cases of interval CRC originate from missed lesions and incompletely resected lesions. Interval CRC can be minimized by improving the quality of colonoscopy. This has led to a growing interest in and demand for high-quality colonoscopy. It is important to reduce the risk of CRC and its associated mortality by improving the quality of colonoscopy. In this review article, we provide an overview of colonoscopy quality indicators, including bowel preparation adequacy, the cecal intubation rate, the adenoma detection rate, the colonoscopy withdrawal time, appropriate polypectomy, and complication of the procedure. Because colonoscopy is a highly endoscopist-dependent procedure, colonoscopists should be well-acquainted with quality indicators and strive to apply them in daily clinical practice for the prevention of CRC.

Keywords: Colorectal neoplasms; Colonoscopy; Quality indicator, health care

INTRODUCTION

Almost 2 million people were newly diagnosed with colorectal cancer (CRC) in 2020 [1]. CRC is the third most frequently diagnosed cancer and the second leading cause of cancer-related death worldwide. The adenoma–carcinoma sequence is the major pathway of CRC development [2]. The natural history of CRC is characterized by progression over a period of 10–20 years on average [3]. Colonoscopy is the most sensitive tool for adenoma detection; it also facilitates adenoma resection [4]. Colonoscopy can be performed as both a screening tool and a diagnostic test. Screening colonoscopy offers an opportunity to identify adenomas, increasing the chance of preventing CRC, as well as detecting early-stage CRC that can be treated with endoscopic techniques [5,6]. Many studies have shown that the incidence and mortality of CRC decrease through regular performance of guideline-recommended screening, surveillance, and qualified endoscopic treatment [7-9].

However, colonoscopy is a highly operator-dependent procedure with wide variability in quality, and the effectiveness of cancer screening varies among endoscopists [10]. Colonoscopy is becoming more widely available, and there is a rising concern about the quality of the procedure [11]. Simultaneously, there is a growing awareness among patients undergoing colonoscopy that CRC can be prevented. Thus, the interest in and demand for qualified colonoscopy are growing. If the quality of colonoscopy is low, its efficiency as a screening test and the probability of early diagnosis of CRC will also be low. This will lead to a shortened surveillance interval. Higher numbers of procedures may cause various problems such as increased patient discomfort and higher medical costs. Increasing access to guideline-recommended screening and qualified colonoscopy may lower the incidence of CRC. Standardized colonoscopy reporting is also needed to improve colonoscopy quality [12,13]. The major components of qualified colonoscopy include high effectiveness (detecting adenoma and CRC), safety (minimiz-

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ing adverse events), and value (avoiding unnecessary costs). In the present study, we reviewed several guidelines and recent studies of colonoscopy quality. A summary of colonoscopy quality indicators proposed in the current guidelines is provided in Table 1. We hope to lower CRC-related mortality through high-quality colonoscopy.

PREPROCEDURAL QUALITY INDICATORS

Bowel preparation adequacy

The quality of bowel preparation influences the cecal intubation rate (CIR) and detection of adenoma and sessile serrated lesions (SSLs) [14,15]. Inadequate bowel preparation can lead to repeat colonoscopy or alternative investigations, increasing medical costs and inconvenience to patients [16]. The American Society for Gastrointestinal Endoscopy (ASGE)/American College of Gastroenterology (ACG) guidelines recommend documenting the quality of bowel preparation in > 98% and achieving adequate bowel preparation in ≥ 85% of all outpatient screening colonoscopies [17]. However, the target level for adequate bowel preparation has recently been a topic of interest. The American Gastroenterological Association (AGA) recently recommended achieving adequate bowel preparation in ≥ 90% (aspirational target: ≥ 95%) of screening colonoscopies [18]. Similarly, the European Society of Gastrointestinal Endoscopy (ESGE) guidelines propose ≥ 90% as the minimum and ≥ 95% as the target standard [19]. Validated scales of bowel preparation quality include the Boston Bowel Preparation Scale, the Ottawa Scale, and the Aronchick Scale [20-22]. Preparation quality should be documented in every colonoscopy report. Adequate bowel preparation might be defined as a Boston Bowel Preparation Scale score of ≥ 6, Ottawa Scale score of ≤ 7, or Aronchick Scale of excellent, good, or fair [23-25]. If the minimum standard cannot be reached, factors associated with bowel preparation should be analyzed. Such factors include patient guidance, dietary restrictions, the bowel preparation agents used, and the colonoscopy timing [26,27]. A Korean single-center prospective study showed that 28.1% of patients had inadequate bowel preparation and that risk factors included advanced age, a history of intra-abdominal surgery, cerebrovascular disease, and consumption of an inadequate volume of preparation solution (< 2 L) [26]. After assessment and adjustment, close monitoring should be repeated at shorter intervals than recommended. However, a large national registry study in the United States demonstrated that the adherence to guideline recommendations to undergo repeat colonoscopy within 1 year is low because of inadequate bowel preparation [28].

Split-dose bowel preparation should be the standard strategy in patients undergoing colonoscopy [18,29]. The quality of bowel preparation may be improved by shortening the delay between completion of the bowel purgative and the beginning of the colonoscopy procedure [30]. An example is split-dose bowel preparation in which one-half to three-quarters of the purgative is taken the evening before colonoscopy and the remainder is taken 4–6 hours before the start of colonoscopy [31,32]. Several randomized controlled trials, systematic reviews, and meta-analyses have shown that a split-dose strategy is superior to dosing the evening before colonoscopy for bowel cleansing and detection of adenomas, advanced adenomas, and SSLs [33-36]. For afternoon examinations, using a same-day bowel prepa-

Table 1. Summary of proposed quality indicators for colonoscopy in current guidelines

Proposed quality indicators	AGA (2021)	ASGE/ACG (2015)	ESGE (2017)
Bowel preparation adequacy (%)	≥ 90	≥ 85	≥ 90
Cecal intubation rate (%)	≥ 90	≥ 95	≥ 90
Adenoma detection rate (%)	≥ 30	≥ 25 (≥ 30 for men and ≥ 20 for women)	≥ 25
Colonoscopy withdrawal time (min)	≥ 6	≥ 6	≥ 6
Appropriate polypectomy (%)	N/A	N/A	≥ 80
Complication of procedure (%)			
Perforation in screening	N/A	< 0.001	N/A
Post-polypectomy bleeding	N/A	< 1	N/A

ACG, American College of Gastroenterology; AGA, American Gastroenterological Association; ASGE, American Society for Gastrointestinal Endoscopy; ESGE, European Society of Gastrointestinal Endoscopy; N/A, not available.

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ration strategy (in which the purgative is only taken the morning of the procedure and is finished 2–4 hours before the scheduled appointment) is equally as effective as a split-dose strategy. It may be preferred because of less disruption of regular activities and sleep [37,38].

To ensure high effectiveness and safety of bowel preparation, an osmotically balanced and nonabsorbable solution of a conventional purgative using 4 L of polyethylene glycol (PEG) or 2 L of PEG with ascorbic acid is recommended [29]. However, patient compliance may be poor because of the large volume that must be consumed. To increase convenience for patients, 1 L of a PEG-based solution was recently introduced. This solution showed noninferiority in terms of overall bowel cleansing efficacy in randomized controlled trials in Western countries [39,40]. A Korean multicenter, randomized, endoscopist-blinded study demonstrated that 1 L of PEG resulted in higher-quality bowel cleansing in both the overall and right-sided colon compared with 2 L of PEG [41]. Oral sulfate solution (OSS) and oral sulfate tablets (OSTs) are non-PEG based purgatives. The bowel cleansing efficacy of OSS is not inferior to that of ascorbic acid plus PEG regardless of the colon segment [42]. The use of OSTs has also emerged as a purgative strategy to overcome the taste barriers of OSS. OSTs are not inferior to OSS with respect to bowel cleansing efficacy. In addition, they exhibit better safety and tolerability [43]. Novel mini-OSTs show safety, efficacy, and tolerability similar to those of conventional OSTs [44]. For safe and high-quality colonoscopy, it is important to choose a suitable bowel preparation regimen according to the individual patient's situation [45].

INTRAPROCEDURAL QUALITY INDICATORS

Cecal intubation rate

Complete colonoscopy requires cecal intubation for visualization of the whole cecum and its landmarks (appendiceal orifice and ileocecal valve) [17,18]. Cecal intubation should be photo-documented in every colonoscopy report. The ASGE/ACG guidelines recommended a target CIR of ≥ 95% during screening colonoscopy [17]. The ESGE guidelines recommend a minimum unadjusted CIR of ≥ 90% and a target rate of ≥ 95% as a measure of the completeness of colonoscopy examination [19]. In the National Health Service Bowel Cancer Screening Program, however, the CIR varied from 76.2 to 100%, which was highly consistent with the adenoma detection rate (ADR) [46]. The recently updated AGA guidelines suggest that the overall target should be ≥ 90%, which should be increased to ≥ 95% if examinations with inadequate bowel preparation are excluded [18]. Failure of cecal intubation may occur for several reasons, including a redundant colon (56.8%), difficult sigmoid colon (34.0%), and sedation difficulty (8.4%) [47]. Clear cecal imaging documentation is associated with a higher polyp detection rate (PDR) [48]. When a lesion is missed during colonoscopy or when the cecum cannot be reached (indicating right-sided colonoscopy failure), the risk of interval CRC increases [49]. An Ontario Cancer Registry study revealed that endoscopic patients with a CIR of ≥ 95% were nearly 30% less likely to be diagnosed with interval CRC than are patients with a CIR of < 80% [50].

Adenoma detection rate

The ADR is defined as the number of patients with one or more adenomas divided by the total number of patients who have undergone a screening colonoscopy [17]. A high ADR reflects adequate inspection of the intestinal mucosa. Thus, it is inversely associated with the risk of interval CRC and CRC death [51,52]. The ADR can be used to determine whether screening or diagnostic colonoscopy is adequate in patients aged > 50 years. The ASGE/ACG guidelines recommend ADR targets for screening colonoscopy of ≥ 30% for men and ≥ 20% for women (25% for all patients) aged ≥ 50 years [46]. The ESGE guidelines recommend an ADR of ≥ 25% [19]. A recent review by the AGA recommended an ADR of 30% with an aspirational target of 35% [18]. However, this expert review was not a systematic review; it did not rate the quality of evidence or strength of recommendations. The ADR is highly dependent on the individual colonoscopist. Thus, quality assessment may lead to improvement. Interventions such as education, awareness campaigns, and feedback can help improve the ADR [53,54]. Studies have demonstrated that an improved ADR can reduce the risks of interval CRC and death [51,55]. A recent retrospective study involving three large health care systems showed that patients who have undergone colonoscopy by endoscopists who achieve higher ADRs have significantly lower risks of interval CRC (hazard ratio, 0.97 per 1% absolute ADR increase; 95% confidence interval, 0.96–0.98) and death from interval CRC (hazard ratio, 0.95 per 1% absolute ADR increase; 95% confidence interval, 0.92–0.99) across a broad range of ADRs [56]. Therefore,

the ADRs of all colonoscopists should be measured, and those with an overall ADR of < 25% in screening colonoscopy should improve their performance.

The PDR is an alternative to the ADR. It is easier to measure and apply the PDR than the ADR in clinical practice because it does not require histologic confirmation. However, a distal polyp is less closely associated with the ADR than is a proximal polyp. Thus, the PDR might be used as a surrogate for the ADR in the right-sided colon [57]. Achieving a PDR of 40% is correlated with an ADR of 25% [58]. Similar to the ADR, the serrated lesion detection rate (SDR) is calculated as the number of screening colonoscopies with one or more SSLs divided by the total number of screening colonoscopies for a given time period. According to a recent expert review by the AGA, the SDR should be ≥ 7% (aspirational target: ≥ 10%) [18]. Although a high ADR plays an important role in evaluating the quality of colonoscopy, it does not reflect the overall quality because the ADR does not consider missed adenomas when a patient has two or more adenomas. A high ADR does not guarantee a low adenoma miss rate (AMR) [59]. One prospective multicenter study showed that colonoscopy indicators were not significantly associated with the AMR [60]. Nevertheless, the AMR might compensate for the limitations of the ADR and should thus be considered for qualified colonoscopy [61].

Colonoscopy withdrawal time

The colonoscopy withdrawal time (WT) is defined as the time spent on withdrawal of the colonoscope from the cecum to the anus and inspection of the bowel mucosa during normal colonoscopy with no biopsy or procedure. The ASGE/ACG guidelines recommend a target average WT (AWT) of 6 minutes [17]. An AWT of ≥ 6 minutes is associated with a higher ADR and lower incidence of interval cancer than is a shorter AWT [62,63]. Colonoscopists with of AWTs of ≥ 6 minutes have higher detection rates of neoplasia (28.3 vs. 11.8%, $p < 0.001$) and advanced neoplasia (6.4 vs. 2.6%, $p = 0.005$) than colonoscopists with AWTs of < 6 minutes [62]. A study of the Minnesota Cancer Surveillance System demonstrated that a shorter annual AWT during screening colonoscopies was independently associated with a lower ADR and a higher risk of interval CRC [63]. However, whether 6 minutes is the actual optimal target WT in screening colonoscopy remains unclear. In the AGA expert review, the minimum AWT target was also 6 minutes, although an aspirational target of 9 minutes is recommended [18]. The ESGE guidelines also recommend 6 minutes as the minimum standard and 10 minutes as the target standard [19]. In a recent Korean study, the ADR was significantly higher when the segmental WT was ≥ 2 minutes in the right-sided colon, ≥ 4 minutes in the proximal colon, and ≥ 3 minutes in the left-sided colon than when the segmental WT was shorter [64]. That study suggested that the segmental WT was more important than the total WT. Similar to the ADR, the SDR is also associated with the WT [65].

Appropriate polypectomy

Effective and safe polypectomy requires proper technique, high endoscopic skill, and appropriate device selection. Appropriate selection of polypectomy tools based on the size and morphology of the polyp is important to ensure adequate resection and avoid post-polypectomy adverse events [18]. The ESGE recommends that appropriate polypectomy should be performed for ≥ 80% of cases and that the retrieval rate of non-diminutive polyps should be ≥ 90% (> 95% for polyps measuring > 10 mm and > 80% for polyps measuring < 10 mm) [19,66]. A recent study of the National Health Registry of Denmark using a root-cause algorithm demonstrated that incomplete resection of a previously identified lesion accounted for 11% of cases of interval CRC [67]. The AGA recommends that until higher-quality data are available, units should consider emphasizing polypectomy best practices, including the use of cold techniques for polyps of < 1 cm and avoiding forceps except for polyps of > 2 mm [18]. The ESGE guidelines suggest that an adequate resection technique for small and diminutive polyps should include biopsy forceps removal of polyps measuring ≤ 3 mm and snare polypectomy for larger polyps [19]. Sessile polyps should be classified according to the Paris classification to determine the risk of invasion, and this should be written in the medical record. Polyps with a depressed component and non-granular or mixed lateral spreading tumors have a higher risk of submucosal invasion [68]. For such polyps, the margin should be assessed and the depth of invasion should be predicted by conventional or imaging-enhanced colonoscopy. Because of the risk of malignancy, such lesions should be removed en bloc if possible [69].

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POSTPROCEDURAL QUALITY INDICATORS

Complication of procedure

To assess the safety of the colonoscopy procedure, it is important to monitor the rate of complications after screening, diagnostic, and therapeutic colonoscopy. The recent expert review by the AGA suggested systematic monitoring of delayed adverse events, including postprocedural bleeding, perforation, hospital readmission, 30-day mortality, and/or interval CRC, and stated that adverse event rates should be reported at the unit level [18]. Postprocedural bleeding is a frequent complication after polypectomy. Current guidelines suggest that the colon perforation rate is < 0.001% and that the post-polypectomy bleeding rate is < 1% [70]. Delayed bleeding and perforation are uncommon after routine colonoscopy (incidence rate of approximately 0.24 and 0.06%, respectively) [17,71]. The recommended recovery rate after post-polypectomy bleeding without surgical resection is > 90% [54]. The ESGE guidelines recommend a 7-day overall or 30-day colonoscopy-specific readmission rate of ≤ 0.5% [19].

CONCLUSIONS

There are many qualitative differences among endoscopists in performing colonoscopy. Therefore, it is important to be familiar with quality indicators and continuously measure them in routine practice [72,73]. Studies have shown that the monitoring and reporting of colonoscopy quality indicators in Korea are suboptimal [74,75]. With the recent increase in CRC, the interest in and concerns about colonoscopy are also increasing. Thus, there is a need to fully understand quality indicators and implement colonoscopy accordingly. It is also necessary to develop new quality indicators specific to Korea.

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