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Review

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Colonoscopy quality and endoscopist factors: what are the required endoscopist conditions for high-quality colonoscopy to reduce colorectal cancer incidence and mortality?

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Abstract

To maximize the effectiveness of colonoscopy in decreasing the incidence and mortality of colorectal cancer (CRC), high-quality colonoscopy procedures are essential. Considering that the colonoscopy quality varies among endoscopists, it is important to understand the endoscopist factors that influence the colonoscopy quality. In this paper, we reviewed the endoscopist factors related to colonoscopy quality. There are several quality indicators of colonoscopy, among which the adenoma detection rate is the most established indicator with evidence of its correlation with post-colonoscopy CRC. With respect to lesion detectability during colonoscopy, there are other measurements such as the sessile serrated lesion detection rate; however, further evidence on their relationships with post-colonoscopy CRC is needed. Previous studies that have examined the endoscopist characteristics influencing colonoscopy quality have suggested that several factors, including experience, the volume of colonoscopy procedures, and endoscopist specialty, are related to lesion detectability. However, discrepancies exist regarding the studies' results; in particular, the influence of endoscopist specialty on coloscopy quality is controversial. Some recent studies have demonstrated that endoscopist specialty is not related to lesion

detectability when considering confounding factors. Furthermore, it has been reported that nurse endoscopists can provide high-quality colonoscopy after training. It may be possible for endoscopists to improve their colonoscopy quality, regardless of specialty. Training, monitoring, and feedback of colonoscopy quality measurements are useful interventions for endoscopists to ensure high-quality procedures. Owing to the continuous development of endoscopic technologies, it is believed that training is useful for both inexperienced and experienced endoscopists.

Keywords: Adenoma detection rate, colonoscopy, colorectal cancer, endoscopist, feedback, quality indicators, screening, training

INTRODUCTION

Colorectal cancer (CRC) is a leading cause of morbidity and mortality worldwide, and reducing CRC incidence and mortality is an essential task[1]. For this purpose, CRC screening is widely implemented[2]. In CRC screening, colonoscopy is utilized as either the primary screening procedure or secondary examination following a positive noninvasive screening test, such as a fecal blood test[2]. Colonoscopy not only has high detectability and diagnostic ability but can also treat precancerous lesions during the procedure, known as polypectomy[2-4]. Polypectomy has been shown to be effective for the prevention of CRC incidence and mortality[5-7]. The usefulness of colonoscopy as a secondary examination in CRC screening can be referenced from the literature, which clearly shows the CRC incidence and mortality reduction effect of screening fecal blood test followed by colonoscopy[8-13]. With regard to colonoscopy as a primary screening procedure, although evidence from randomized controlled trials (RCTs) is lacking, increasing evidence from high-quality cohort and case-control studies shows its effectiveness in reducing CRC incidence and mortality[14-18]. Furthermore, several large-scale RCTs examining the effect of screening colonoscopy are currently ongoing, including trials in Spain (COLONPREV), the USA (CONFIRM), Europe (NordICC), Japan (Akita pop-colon trial), and Sweden (SCREESCO)[19-22]. Despite such promising effectiveness, colonoscopy is not perfect, as colorectal neoplastic lesions can be missed during colonoscopy. In a previous study, the adenoma miss rate was reportedly between 9% and 26%[23]. The quality of colonoscopy, including its ability to detect lesions, is known to vary in real-world practice and is considerably influenced by the endoscopists who perform the procedure[24-27]. To maximize the effectiveness of colonoscopy to prevent CRC incidence and mortality, it is necessary to assure high-quality colonoscopy. In this paper, we review the issues of colonoscopy quality and related endoscopist factors to discuss what the required endoscopist conditions are to perform a high-quality colonoscopy. We also describe the experiences in Japan and Sweden on this issue.

QUALITY INDICATORS OF COLONOSCOPY

There are several established quality indicators for colonoscopy, which include preprocedural, intraprocedural, and postprocedural indicators[24-27]. Experience (satisfaction and comfort level) of individuals receiving colonoscopy has also been proposed as quality indicators. Table 1 summarizes several major colonoscopy quality indicators. In this table, the performance targets for the indicators proposed in major international guidelines are described.

Among the indicators, the adenoma detection rate (ADR) is the most established measurement that assesses the colonoscopy quality; in addition, ADR is often used as a measurement of improvement when discussing how colonoscopy quality can be improved[24-30]. ADR is defined as the proportion of colonoscopies with at least one adenoma detected, and it can be calculated by the number of colonoscopies with at least one adenoma detected divided by the number of all colonoscopies. Because ADR is largely affected by colonoscopy indications (screening, surveillance, *etc.*), ADR should principally be compared with that in

Table 1. Major quality indicators of colonoscopy

	ASGE	ESGE		UK	
	Performance target	Minimum standard	Target standard	Minimum standard	Aspirational target
Adequate bowel preparation	≥ 85%	≥ 90%	≥ 95%	≥ 90%	≥ 95%
Cecal intubation rate	≥ 90% (all), ≥ 95% (screening)	≥ 90%	≥ 95%	≥ 90%	≥ 95%
Adenoma detection rate	≥ 25% (males ≥ 30%, females ≥ 20%)	≥ 25%	-	≥ 15%	≥ 20%
Average withdrawal time for negative examinations	≥ 6 min	≥ 6 min	≥ 10 min	≥ 6 min	≥ 10 min
Complications	Perforation: < 1/1000 Postpolypectomy bleeding: < 1%	7-day readmission: ≤ 0.5%		Perforation: < 1/1000 (overall), < 1/2000 (diagnostic), < 1/500 (polypectomy) Postpolypectomy bleeding: < 1/200	Perforation: < 1/3000 (overall), < 1/4000 (diagnostic), < 1/1500 (polypectomy) Postpolypectomy bleeding: < 1/1000

ASGE: American Society for Gastrointestinal Endoscopy; ESGE: European Society of Gastrointestinal Endoscopy.

colonoscopy procedures with the same indications. It is known that there is a wide ADR variation among endoscopists, and a lower ADR is associated with a higher risk of post-colonoscopy CRC (PCCRC) incidence and mortality[24-30]. In 2010, a landmark study from Poland clearly showed that endoscopists with an ADR < 20% during screening colonoscopy had an over 10-fold higher incidence of PCCRC than those with an ADR ≥ 20%[28]. Thereafter, the evidence on ADR as the quality indicator has accumulated[24-30]. In 2014, a United States study demonstrated that each 1% increase in ADR was associated with a 3% and 5% decrease in the risk of PCCRC and fatal PCCRC, respectively[29]. Although ADR is such an established quality indicator, there are several issues requiring discussion. Due to the higher chances of detecting diminutive adenomas during colonoscopy, the performance target for ADR may be reconsidered[31]. For instance, based on experience in Japan, it seems that adenomas can be detected in over 40% of average-risk individuals aged ≥ 50 years, and an ADR of 20% is considered low even if it is the minimum target cut-off value[32].

In addition to ADR, there are several other measurements regarding lesion detectability during colonoscopy, although evidence on their usefulness as quality indicators of colonoscopy is less sufficient than that of ADR[26]. Because the detection and removal of advanced adenomas seem more relevant for CRC prevention than those of small adenomas, the rate of advanced adenoma detection may be useful for assessing colonoscopy quality. As the clinical importance of sessile serrated lesions (SSLs) has become widely recognized, increasing attention has been paid to its detection [Figure 1][33-35]. As many SSLs are macroscopically normal to pale in color and flat in shape, these lesions are more difficult to detect and more easily overlooked during colonoscopy[34,35]. Therefore, the SSL detection rate may show more variation among endoscopists than that of ADR, and its potential as a quality indicator is worth further assessment. In addition, considering the malignant potential and easily overlooked appearance of colorectal flat adenomas such as laterally spreading tumors, the detection rate of flat adenomas is also a candidate as a quality indicator [Figure 2][36-38]. The polyp detection rate and polypectomy rate can be mentioned as simpler measurements not requiring histopathological results, and these may be useful when the calculation of lesion detection rates incorporating the pathological results is difficult[26]. However, it should be remembered that these measurements can be easily subject to manipulation by endoscopists.

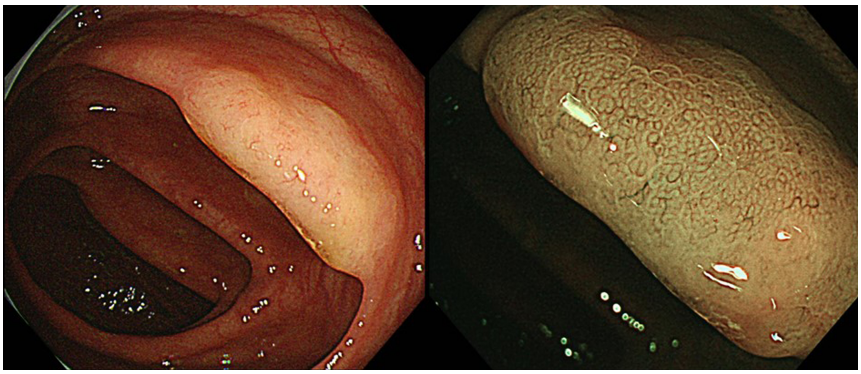

Figure 1. A case of colorectal sessile serrated lesion. The lesion shown in Figure 1 is a sessile serrated lesion (SSL) detected during a colonoscopy. SSLs are often flat and macroscopically normal to pale in color, as shown in this case, and can be easily overlooked. The detection of SSLs is important, and the detection rate of SSLs may be a quality measurement of colonoscopy.

Figure 2. A case of a colorectal lateral spreading tumor. The lesion shown in Figure 2 is a lateral spreading tumor (LST) detected during colonoscopy, followed by endoscopic submucosal dissection. The pathological diagnosis after treatment was tubular adenoma with high-grade dysplasia. LSTs are known to have high malignant potential, but they are easily overlooked and can cause post-colonoscopy cancer. The detection of LSTs is essential, and the detection rate of these flat lesions may be a quality measurement of colonoscopy.

It may also be necessary to consider the number of lesions detected during colonoscopy to reflect colonoscopy quality more clearly. The mean adenomas per procedure, which is calculated as the total number of adenomas detected divided by the total number of colonoscopy procedures, and mean adenomas per positive procedure, which is calculated by the total number of adenomas detected divided by the number of colonoscopy procedures with at least one adenoma detected, are measurements incorporating the number of adenomas detected[26,39]. These measurements may be better representations for lesion detectability of endoscopists; thus, further studies on the relationships between these measurements and PCCRC are warranted.

ENDOSCOPIST FACTORS THAT INFLUENCE COLONOSCOPY QUALITY

Colonoscopy performance can be affected by many factors, including bowel preparation, endoscopy devices, and procedural skills. Particularly, procedural skills that are variable among endoscopists are considerably influential. In this context, it is believed to be important to understand endoscopist factors associated with colonoscopy quality.

Several previous studies have examined the relationships between endoscopist characteristics and colonoscopy quality, particularly lesion detectability during colonoscopy, such as ADR[40-47]. Table 2

Table 2. Recent studies that have examined endoscopist factors and lesion detectability during colonoscopy

Author	Region	Report year	Data source	Number of endoscopists	Number of colonoscopy procedures	Colonoscopy indication	Examined measurements for lesion detectability	Adenoma detection rate	Main findings on endoscopist factors related with lesion detectability
Kozbial *et al.*[40]	Austria	2015	Austrian national Certificate of Quality for Screening Colonoscopy program	178	59,901	Screening	ADR, AADR, PDR, CDR, FDR	20.5% (88 endoscopists: ADR < 20%)	Specialty did not remain related to ADR after adjustments for other factors
Zorzi *et al.*[41]	Italy	2015	Italian organized CRC screening program	479	75,569	Positive FIT	ADR, AADR, PDR	44.8% (range: 13.5%-75%)	Specialty (gastroenterology) and availability of screening-dedicated sessions were related to a higher ADR
Jover *et al.*[42]	Spain	2016	COLONPREV study cohort	48	3838	Screening	ADR, AADR, APCR	31.5% (range: 4.5%-56.5%)	Age and number of performed colonoscopies were related to ADR, and exclusive dedication to endoscopy practice was related to proximal ADR
Mehrotra *et al.*[43]	USA	2018	Four American healthcare sites	201	104,618	Various	ADR	33.2% (range: 6.3%-58.7%)	Specialty (gastroenterologist), sex (female), and recent training were related to a higher ADR (both proximal and distal ADRs).
Crockett *et al.*[44]	USA	2019	Four American healthcare sites	201	104,618	Various	SPDR	-	Specialty (gastroenterologist), number of colonoscopy procedures, and recent training were related to a higher SPDR
Mandaliya *et al.*[45]	USA	2019	A single center	18	2850	Screening	ADR, PSPDR	36% (range: 21%-53%)	Specialty (academic gastroenterologist) was related to a higher PSPDR but not ADR
Sarvepalli *et al.*[46]	USA	2019	A single center	56	16,089	Screening	ADR, PSSPDR	31.3%	After adjusting for patient and endoscopist characteristics, no endoscopist characteristic was associated with ADR, and only the years in practice and number of colonoscopies performed per year were related with PSSPDR
Muthukuru *et al.*[47]	USA	2020	A single center	84	4151	Screening	ADR, SSPDR, *etc.*	26.4%	Specialty (gastroenterologist) was associated with a higher ADR and SSDR, particularly in the proximal colon

AADR: Advanced adenoma detection rate; APCR: adenoma per colonoscopy rate; ADR: adenoma detection rate; CDR: cancer detection rate; FDR: flat polyp detection rate; FIT: fecal immunochemical test; PDR: polyp detection rate; PSPDR: proximal serrated polyp detection rate; PSSPDR: proximal sessile serrated polyp detection rate; SPDR: serrated polyp detection rate; SSPDR: sessile serrated polyp detection rate.

summarizes the recent studies that retrospectively examined the endoscopist factors related to lesion detectability using certain databases[40-47]. They suggest that age, sex, specialty, procedural experience, number of colonoscopy procedures recently performed, and more recent exposure to training may be related to higher lesion (adenoma or serrated lesion) detectability during colonoscopy, although discrepancies exist for the obtained findings among the studies. Despite the necessity for further assessment, it is understandable that endoscopists with more experience and a higher number of performed colonoscopy procedures will have higher lesion detectability. However, regarding the endoscopist specialty, its relationship with the quality of colonoscopy is controversial. Several previous studies, including those described in Table 2, suggest the superiority of gastroenterologists to non-gastroenterologists and surgeons in terms of lesion

detectability[41,43-45,47]. Furthermore, several studies have demonstrated that gastroenterologists showed a lower incidence of PCCRC[48-50]. However, some recent studies have emphasized that endoscopist specialty does not remain statistically related to lesion detectability when sufficiently considering confounding factors[40,46]. A recent study from the USA has proposed that, after considering and adjusting for patient and endoscopist characteristics, ADR is not related to any endoscopist characteristic, and only the years in practice and number of colonoscopies performed per year were related to the proximal sessile serrated polyp detection rate[46]. If it is interpreted positively with respect to endoscopist specialty, the colonoscopy quality may be improved regardless of the specialty.

Regarding the issue of the endoscopist's specialty, the concept of nurse endoscopists is also worthy of attention[51-58]. In several places, including the UK, the Netherlands, and Scandinavia, trained and certified nurse endoscopists perform colonoscopy procedures in daily practice. Table 3 summarizes previous studies that have examined the performance of colonoscopy procedures performed by nurse endoscopists. It has been suggested that, similar to doctor endoscopists, nurse endoscopists can provide sufficiently high-quality colonoscopy after training. The required number of colonoscopy procedures for nurse endoscopist trainees before they can start performing colonoscopy procedures independently is reportedly 140-150[53,57]. A recent report from the USA showed that three nurse endoscopists who had completed at least 140 supervised colonoscopy procedures provided cecal intubation rates of 95.6%-98.9% and ADRs of 27.8%-44.5% without any severe complications during screening colonoscopies[58]. In Sweden, approximately 60 nurse endoscopists currently play an important role in endoscopy practice. There are training programs for nurse endoscopist trainees in which they are required to acquire knowledge and skills regarding endoscopy through lectures and hands-on training. After receiving training and passing certification examinations, they can become certified nurse endoscopists. The requirement for certified nurse endoscopists to perform screening colonoscopy is having performed ≥ 1000 colonoscopy procedures and performing ≥ 200 procedures per year.

INTERVENTION ON ENDOSCOPISTS TO IMPROVE COLONOSCOPY QULAITY

The development and utilization of efficient endoscopy devices and technologies are important strategies for improving colonoscopy quality. However, even with efficient devices and technologies, if endoscopists do not possess the ability to properly utilize them, high-quality colonoscopy procedures cannot be performed. In this sense, it is essential to ensure that endoscopists possess sufficient ability to provide high-quality colonoscopy procedures. As indicated by previous studies on the endoscopist factors influencing colonoscopy quality, sufficient experience and number of colonoscopy procedures are required for providing high-quality colonoscopy[42-44]. However, it would be inefficient and potentially harmful if inexperienced endoscopists continue performing a colonoscopy on their own without any guidance, and adequate training for endoscopists is indispensable. A recent systematic review and meta-analysis incorporating three RCTs clearly demonstrated that focused training is useful for improving ADR among endoscopists[59-62]. However, the method of training was variable in previous studies, and, thus, more discussion is necessary on the optimal method of training. Trainees should acquire both knowledge and skills during their training period, and, therefore, lectures and hands-on training under the supervision of experts are necessary. A certification system in which endoscopists can become certified only after a specific training program may also be useful. In Japan, the Japan Gastroenterological Endoscopy Society (JGES) has a certification system in which several conditions, including at least five years of endoscopy training and passing an examination, are required for trainees to become certified endoscopists. In addition, the JGES has just started a new certification system for screening endoscopy. In this new certification system, certified screening colonoscopists are required to have performed at least 300 colonoscopies and need to receive lectures and hands-on seminars. The duration of training effectiveness is another important issue in

Table 3. Previous studies that have examined the performance of colonoscopy by nurse endoscopists

Author	Region	Report year	Study design	Number of nurse endoscopists	Number of colonoscopy procedures performed by nurse endoscopists	Colonoscopy indication	Perforation rate by nurse endoscopists	Cecal intubation rate by nurse endoscopists	Adenoma detection rate by nurse endoscopists
Koornstra *et al.*[53]	Netherlands	2009	Single-center prospective study	2 (trainee)	300	Various	0%	90.7% (96% for the last 25 cases)	-
Limoges-Gonzalez *et al.*[54]	USA	2011	Single-center RCT (compared with doctor endoscopists)	1 (trained)	50	Screening	0%	100%	42.0%
van Putten *et al.*[55]	Netherlands	2012	Multicenter prospective	10 (trained)	1000	Various	0.1%	94%	26.7%
Massl *et al.*[56]	Netherlands	2014	Multicenter prospective	7 (trainee)	866	Various	0%	77% (unassisted: increased to 89% during assessment period), 95% (assisted)	27%
Hui *et al.*[57]	Hong Kong	2015	Single-center RCT (compared with doctor endoscopists)	3 (trained)	364	Screening	0%	97.3%	43.8%
Riegert *et al.*[58]	USA	2020	Single-center retrospective study	3 (trained)	1012	Screening	0%	98.5%	35.6%

RCT: Randomized controlled trial.

training. As some studies on endoscopist factors associated with lesion detectability demonstrated, recent training may lead to higher lesion detectability[43,44]. Considering the continuous development of endoscopic technology, it is important even for experienced endoscopists to continue to receive training and update their knowledge and skills.

In addition to training, monitoring and feedback of colonoscopy quality measurements are known to be helpful interventions for endoscopists to ensure the high-quality of colonoscopy[63]. Previous studies have shown that the endoscopist's feedback is related to the improvement of ADR, and that endoscopists with a low ADR at baseline can benefit from feedback. The endoscopists' awareness of their own colonoscopy quality is believed to lead to an improvement in colonoscopy quality. However, quality monitoring and feedback have not been widely implemented in the real world thus far. Recently, the European Colonoscopy Quality Investigation Group has surveyed the real-world situation related with colonoscopy quality in Europe and reported the variation in quality and the low implementation rate of quality monitoring[64,65]. These findings indicate the necessity of promoting quality monitoring and feedback. To promote these, it is necessary to build a good endoscopy database system. In Sweden, the database of screening colonoscopy that was developed from the

SCREESCO study has recently been introduced, and endoscopists can check their own important quality measurements, such as ADR. In Japan, the JGES has already started the Japan Endoscopy Database Project, which aims to build a large-scale nationwide endoscopy database that is expected to lead to the establishment of an efficient monitoring and feedback system in the future[38,66,67].

CONCLUSION

Experience and a sufficient number of colonoscopy procedures are required for endoscopists to perform a high-quality colonoscopy to prevent the development of CRC. Although the relationship between endoscopist specialty and colonoscopy quality is controversial, it may be possible that endoscopists of any specialty, including nurse endoscopists, can improve their colonoscopy quality regardless of specialty. Training, monitoring, and feedback of colonoscopy quality measurements are useful interventions for endoscopists to ensure high-quality procedures. Because many aspects of colonoscopy quality and endoscopist factors are not fully understood and controversial, further assessment is warranted.

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Authors' contributions

Design of the study and the data interpretation: Sekiguchi M, Falkén Y, Matsuda T, Saito Y, Hultcrantz R
Drafted the article: Sekiguchi M
Contributed to the critical revision of the article for important intellectual content and approved the final version of the article: Sekiguchi M, Falkén Y, Matsuda T, Saito Y, Hultcrantz R

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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