Comparison of cecal intubation and adenoma detection between hospitals can provide incentives to improve quality of colonoscopy

Authors

Tim D. G. Belderbos[1,*], Elisabeth J. Grobbee[2,*], Martijn G. H. van Oijen[1], Maarten A. C. Meijssen[3], Rob J. T. Ouwendijk[4], Thjon J. Tang[5], Frank ter Borg[6], Peter van der Schaar[7], Doris M. Le Fèvre[8], Merijn T. Stouten[9], Onno van der Galiën[8], Theo J. Hiemstra[8], Wouter H. de Vos tot Nederveen Cappel[3], Pieter C. J. ter Borg[4], Manon C. W. Spaander[2], Leon M. G. Moons[1], Ernst J. Kuipers[2,**], Peter D. Siersema[1,**]

Institutions

Institutions are listed at the end of article.

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Corresponding author
Tim D. G. Belderbos, MD
University Medical Center Utrecht
Heidelberglaan 100
3584 CX Utrecht
The Netherlands
Fax: +31-88-7555533
t.d.g.belderbos@umcutrecht.nl

Background and study aims: Cecal intubation rate (CIR) and adenoma detection rate (ADR) have been found to be inversely associated with the occurrence of post-colonoscopy colorectal cancer. Depicting differences in CIR and ADR between hospitals could provide incentives for quality improvement. The aim of this study was to compare quality parameters of routine colonoscopies between seven hospitals in The Netherlands in order to determine the extent to which possible differences were attributable to procedural and institutional factors.

Patients and methods: Consecutive patients undergoing colonoscopy were prospectively included between November 2012 and January 2013 at two academic and five nonacademic hospitals. Patients with inflammatory bowel disease or hereditary colorectal cancer syndromes were excluded. Main outcome measures were CIR and ADR.

Results: A total of 3129 patients were included (mean age 59 ± 15 years; 45.5 % male). The majority of patients (86.2 %) had a Boston Bowel Preparation Scale (BBPS) score ≥ 6. Overall CIR was 94.8 %, ranging from 89.4 % to 99.2 % between hospitals. After adjustment for case mix (age, sex, American Society of Anesthesiologists score, and indication for colonoscopy), factors associated with CIR were hospital and a BBPS score ≥ 6. Overall ADR was 31.8 % and varied between hospitals, ranging from 24.8 % to 46.8 %. Independent predictors for ADR were hospital, BBPS score ≥ 6, and cecal intubation. By combining CIR and ADR for each hospital, a colonoscopy quality indicator (CQI) was developed, which can be used by hospitals to stimulate quality improvement.

Conclusion: Differences in the quality of colonoscopy between hospitals can be demonstrated using CIR and ADR. As both indicators are affected by institution and bowel preparation, a comparison between hospitals based on the newly developed CQI could assist in further improving the quality of colonoscopy.

Introduction

Screening strategies that employ colonoscopy for the detection and removal of precursors of colorectal cancer (CRC) effectively reduce CRC-related mortality [1,2]. Apart from participation grades, the efficacy of population-based CRC screening depends on the quality of colonoscopy.

Colonoscopy quality is ultimately reflected by a reduction in the incidence of CRC following colonoscopy. However, measurement of post-colonoscopy CRC is cumbersome and does not allow direct feedback. Several procedural indicators have been suggested for the monitoring of quality [3]. Two recent studies showed that the adenoma detection rate (ADR) of endoscopists was inversely associated with the risk of post-colonoscopy CRC [4,5] and related death [5]. In another study, patients dying from CRC were less likely to have undergone a previous complete colonoscopy than matched controls [6]. In addition, a substantial proportion of colorectal tumors originate from the right-sided colon [7], which underlines the importance of performing a complete colonoscopy, as measured by the cecal intubation rate (CIR).

ADR and CIR have been reported to vary between hospitals depending on case mix and institutional or procedural factors [8–10]. Case mix is determined by nonmodifiable patient characteristics, such as age, sex, co-morbidity, and indication for colonoscopy. In order to provide a useful incentive for hospitals to improve the quality of colonoscopy, a comparison of CIR and ADR between institutions should enable detection of differences that are independently affected by modifiable

* The first two authors contributed equally to the work.
** Both senior authors contributed equally to the work.

factors. In this study the quality of routine colonoscopy was compared between seven hospitals in The Netherlands in order to determine the extent to which detected differences in CIR and ADR were indeed attributable to procedural and institutional factors.

Patients and methods

Registration of colonoscopy data

All colonoscopies performed between 1 November 2012 and 10 January 2013 at two academic medical centers and five large nonacademic hospitals were prospectively recorded. Patient characteristics (i. e. age, sex, and American Society of Anesthesiologists [ASA] score) were obtained from electronic medical records. All endoscopists recorded data on the indication for colonoscopy, the type and dose of sedation used, quality of bowel preparation, cecal intubation, detection and removal of polyps, results from pathology reports, and complications.

The study was exempt from obtaining informed consent from patients, as determined by the Medical Ethical Committee of the UMC Utrecht in accordance with the Medical Research Involving Human Subjects Act.

Definitions

Endoscopists were categorized as gastroenterologists, fellows-in-training for gastroenterology, or nurse endoscopists. Indications for colonoscopy were grouped into five categories: (1) anemia or abdominal symptoms; (2) overt or occult rectal blood loss; (3) screening or a positive family history for CRC; (4) surveillance after CRC or colorectal adenoma(s); and (5) other. The latter category consisted mostly of patients with liver metastases or other abnormalities found during imaging. Patients with inflammatory bowel disease, hereditary CRC, or polyposis syndromes were excluded.

Bowel preparation was scored according to the Boston Bowel Preparations Scale (BBPS). Adequate bowel preparation was defined as a BBPS score ≥ 6 [11]. Sedation was provided using midazolam, propofol, and/or opioid analgesics.

Cecal landmarks were noted in the colonoscopy report, and photographic documentation was routinely obtained. The unadjusted CIR was defined as the proportion of colonoscopies in which the cecum was visualized, irrespective of reasons for not intubating the cecum. The adjusted CIR was calculated by excluding colonoscopies in which the endoscopist made the decision not to intubate the cecum because of severe colitis, colonic obstruction, or therapeutic targets not necessitating cecal intubation [12]. Colonoscopies with poor bowel preparation were included in the adjusted cecal intubation rate, as preparation is considered to be part of the colonoscopy practice in hospitals. The ADR was defined as the proportion of procedures in which one or more adenomas were found.

Complications were subdivided into bleeding (only taken into account if it did not stop spontaneously or by an intervention during the colonoscopy), perforation, and post-polypectomy syndrome.

Factors considered within the term "case mix" were patient age, sex, ASA score, and indication for colonoscopy. Correction for case mix was performed by taking these factors into account when analyzing the association of modifiable factors with the CIR and ADR. Modifiable factors were institution (i. e. the hospital where the colonoscopy was performed), and procedural factors, consisting of the type of endoscopist (gastroenterologist, fellow, nurse endoscopist), use of conscious sedation, and BBPS score. All endoscopists performing colonoscopies during the study period were informed about the study and consented to participate.

Study outcomes

Primary outcomes were unadjusted CIR, adjusted CIR, and ADR. Secondary outcomes were BBPS score, mean number of adenomas per procedure (MAP), mean number of adenomas per positive procedure (MAP+), and complications.

Development of a quality instrument

A colonoscopy quality indicator (CQI) was constructed by plotting the CIR and the ADR per hospital. The sizes of the dots represent the number of colonoscopies performed in each hospital. The position of each dot can be compared with other hospitals and to predetermined thresholds. For the CIR, a minimum of 90 % is generally accepted [3], but there is no unequivocal minimum for ADR during routine colonoscopy. Therefore, for the current study, a line was drawn at 32 % to represent the approximate average ADR, to create a visual target for better-than-average performance.

Statistical analysis

Data are presented in this report as percentages for categorical variables and means (including SDs) or medians (including ranges) for continuous variables, according to the nature of their distribution. Differences between groups were tested using the chi-squared test for categorical variables and the *t* test for normally distributed continuous variables. A logistic regression analysis was performed to identify factors associated with adjusted CIR and ADR. Factors with a *P* value of lt; 0.10 in univariate analysis, were included in a multivariate model. A two-sided *P* value of < 0.05 was considered to be statistically significant.

Analyses were performed using SPSS 20.0 statistics software (IBM Corp., Armonk, New York, USA).

Results

A total of 3129 patients underwent colonoscopy during the study period. The mean age was 59 ± 15 years, and 45.5 % of patients were male (**Table 1**). In the majority of cases (63.0 %) the indication for colonoscopy was anemia or abdominal symptoms. In 90.9 % of patients the ASA score was 1 or 2. Conscious sedation was used in more than 90 % of cases. Split-dose bowel preparation was common practice in all seven hospitals. Gastroenterologists performed most colonoscopies (59.8 %), followed by gastroenterology fellows (23.9 %). The number of colonoscopies per hospital ranged between 124 and 793 (median 421).

A total of 2697 procedures (86.2 %) were performed in adequately prepared colons, with a median BBPS score of 9 (interquartile range 6 – 9) (**Table 2**). The unadjusted CIR was 94.8 % (95 % confidence interval [CI] 94.0 % – 95.5 %). Reasons for not intubating the cecum were inadequate preparation (n = 58, 35.8 %), stenosis (n = 35, 21.6 %), technical difficulty (n = 24, 14.8 %), obstructing tumor (n = 15, 9.3 %), therapeutic goal not requiring cecal intubation (n = 11, 6.8 %), pain (n = 9, 5.6 %), diverticulosis (n = 8, 4.9 %), or severe inflammation (n = 2, 1.2 %). The adjusted CIR was 95.7 % (95 % CI 94.9 % – 96.3 %).

One or more polyps were detected in 45.2 % of all colonoscopies. The ADR was 31.8 % (95 %CI 30.2 % – 33.5 %) with a mean number of 0.6 ± 1.2 (median 0, range 0 – 11) adenomas per procedure for

Table 1 Baseline characteristics.

Total number of patients	3129
Age, mean ± SD, years	59 ± 15
Male sex, n (%)	1423 (45.5)
Indication, n (%)	
Anemia/abdominal symptoms[1]	1972 (63.0)
Rectal (occult) blood loss	226 (7.2)
Family history of CRC[2]	263 (8.4)
Surveillance after CRC/adenoma	626 (20.0)
Other[3]	42 (1.3)
ASA score, n (%)	
1	1784 (57.0)
2	1061 (33.9)
3	160 (5.1)
4	6 (0.2)
Unknown	118 (3.8)
Conscious sedation, n (%)	
Yes	2840 (90.8)
No	158 (5.0)
Unknown	131 (4.2)
Endoscopist	
Gastroenterologist	1870 (59.8)
Gastroenterology fellow	747 (23.9)
Nurse endoscopist	512 (16.4)
Organization, n (%)	
1	339 (10.8)
2	245 (7.8)
3	124 (4.0)
4	639 (20.4)
5	568 (18.2)
6	421 (13.5)
7	793 (25.3)

CRC, colorectal carcinoma; ASA, American Society of Anesthesiologists.
[1] Includes changes in bowel habit.
[2] Screening colonoscopies in patients with a family history of CRC.
[3] Includes liver metastases, abnormalities found with other imaging modalities or diverticular disease.

Table 2 Quality indicators, overall.

Total number of patients, n	3129
BBPS ≥ 6, n (%)	
Yes	2697 (86.2)
No	310 (9.9)
Unknown	122 (3.9)
BBPS, median (IQR)	9 (6 – 9)
CIR, n (%)	
Yes	2967 (94.8)
No	162 (5.2)
Adjusted CIR, n (%)	
Yes	2967 (95.7)
No	134 (4.3)
PDR	1413 (45.2)
ADR	996 (31.8)
MAP, mean ± SD	0.60 ± 1.22
MAP+, mean ± SD	1.89 ± 1.48
Complications, n (%)	19 (0.6)
Bleeding	9 (0.3)
Post-polypectomy syndrome	2 (0.1)
Perforation	1 (<0.1)
Other/unknown	7 (0.2)

BBPS, Boston Bowel Preparation Scale; IQR, interquartile range; CIR, cecal intubation rate; PDR, polyp detection rate; ADR, adenoma detection rate; MAP, mean number of adenomas per procedure; MAP+, mean number of adenomas per procedure with at least one adenoma.

all procedures combined (MAP) and 1.9 ± 1.5 (median 1, range 1 – 11) for procedures in which at least one adenoma was found (MAP+). Complications were observed in 0.6 % (n = 19) of procedures, of which 47.4 % (n = 9) were bleedings.

A significant variability for CIR and ADR was found between hospitals (**Table 3**). Adequate bowel preparation varied between 79.0 % and 97.6 % (P < 0.001). Unadjusted CIR ranged from 89.4 % to 99.2 % (P < 0.001). Adjusted CIR was above 90 % in all participating hospitals but was also significantly different between hospitals (P < 0.001). ADR varied from 24.8 % to 46.8 % (P < 0.001). CIR and ADR were combined in the CQI to depict differences between hospitals, taking into account the number of performed procedures per hospital (**Fig. 1**). ADRs or CIRs were not higher in academic centers or centers performing a higher volume of procedures. Complication rates were not statistically significantly different between hospitals (P = 0.074).

A comparison between the different types of endoscopists showed no differences in unadjusted or adjusted CIR (P = 0.447 and P = 0.629, respectively) (**Table 3**). Without correction for case mix, both nurse endoscopists (36.1 %) and fellows (34.0 %) had a higher ADR than gastroenterologists (29.8 %; P = 0.008). No association was found between the number of procedures per endoscopist and CIR or ADR. Complications occurred more frequently after colonoscopies performed by fellows (P = 0.042).

In univariate analysis, hospital, age, ASA score, indication for colonoscopy, and BBPS score were identified as factors associated with CIR. Hospital, ASA score, indication, and BBPS score remained significantly associated with CIR in multivariate analysis (**Table 4**). In patients with an ASA score > 1, the cecum was less frequently intubated. If patients underwent colonoscopy for surveillance, the procedure was more often completed than in cases of abdominal complaints or anemia. CIR was significantly higher in patients with adequate bowel preparation.

Hospital, type of endoscopist, sex, age, ASA score, indication for colonoscopy, BBPS score, and unadjusted CIR were all associated with ADR in univariate analysis. In multivariate analysis, an asso-

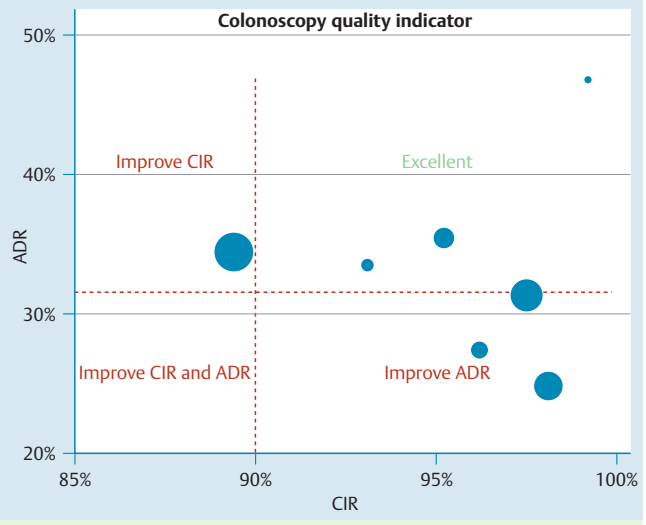

Fig. 1 Bubble plot of combined outcomes for cecal intubation rate (CIR) and adenoma detection rate (ADR) per hospital. The size of the dots represents the number of procedures performed in each hospital. The vertical line at x = 90 % depicts the internationally accepted standard for CIR. As the standard for ADR in routine colonoscopies is arbitrary, the horizontal line at y = 32 % is mainly a visual representation of better-than-average performance.

Table 3 Outcomes per hospital and type of endoscopist.

	Patients, n	BBPS ≥ 6, %	CIR, %	Adj. CIR, %	ADR, %	Complications, %
Hospital						
1	339	79.0	96.2	97.6	27.4	1.2
2	245	87.0	93.1	95.0	33.5	1.6
3	124	88.7	99.2	99.2	46.8	0.0
4	639	97.3	97.5	97.8	31.3	0.8
5	568	95.8	98.1	98.1	24.8	0.2
6	421	97.6	95.2	96.6	35.4	0.0
7	793	80.2	89.4	90.5	34.4	0.6
P value		< 0.001	< 0.001	< 0.001	< 0.001	0.074
Type of endoscopist						
Gastroenterologist	1870	90.1	95.3	95.5	29.8	0.5
Fellow	747	85.7	94.7	95.7	34.0	1.2
Nurse endoscopist	512	93.9	96.2	96.5	36.1	0.2
P value		< 0.001	0.447	0.629	0.008	0.042

BBPS, Boston Bowel Preparation Scale; CIR, cecal intubation rate; Adj. CIR, adjusted cecal intubation rate; ADR: adenoma detection rate.

ciation was shown for hospital, sex, age, indication, BBPS score, and unadjusted CIR (**Table 5**). Male sex and older age were associated with a higher ADR. One or more adenomas were more frequently found if the indication for colonoscopy was a positive family history, rectal blood loss, or surveillance after previous adenoma(s) or CRC, compared with anemia or abdominal symptoms. Both adequate bowel preparation and cecal intubation increased the likelihood of detecting adenomas. After adjustment for case mix, there were no statistically significant differences in ADR between gastroenterologists, fellows, and nurse endoscopists.

Discussion

This prospective study of 3129 routine colonoscopies in seven hospitals demonstrated an overall CIR of 94.8% and an ADR of 31.8%. The results indicate a significant variability in both CIR and ADR between different hospitals. Both CIR and ADR were affected by hospital and bowel preparation, independent of case mix variation. The CQI measure was developed, which presents both CIR and ADR in a matrix that can be used for quality assessment, and this tool may assist in improving colonoscopy performance of hospitals and individual endoscopists.

CIR and ADR in this study were higher than in previous studies, but the variability between hospitals was comparable. Mean CIR and ADR as reported in several studies including routine colonoscopies have been found to vary from 83% to 91% and from 18% to 26%, respectively [8, 13 – 18]. De Jonge et al. reported an unadjusted CIR varying from 81% to 96% and an ADR varying from 13% to 32% among 12 Dutch academic and nonacademic hospitals [15], whereas Harris et al. found a CIR of 69% – 98% and an ADR of 8% – 27% among 21 experienced centers across Europe and Canada [18]. The variation in ADR was even higher in the study by Radaelli et al. [17], ranging from 6% to 46% among 116 Italian endoscopy centers participating in a nationwide registration study for routine colonoscopies. Different studies among screening populations have shown slightly higher CIRs and ADRs, but a comparable variability [10, 19 – 21]. The slightly better results in the current study may be explained, at least partly, by a specific focus on colonoscopy practice in the centers participating in this quality initiative. Another explanation might be that the endoscopists performed better as a consequence of being aware of the study registration, the so-called Hawthorne effect.

Ideally, multivariate analyses of CIR and ADR stratified by hospital would have been performed, but unfortunately the limited number of colonoscopies in some hospitals did not allow useful stratification in the current study. Multivariate analyses per hospital were performed to check whether the effects of covariates were similar across hospitals. It was found that covariates that were significantly associated with CIR or ADR in one or more hospitals affected CIR or ADR similarly across hospitals (i.e. either lowering or improving CIR or ADR).

It would have been advantageous to compare primary outcome measures between individual endoscopists, but unfortunately the low number of procedures per endoscopist hampered such analyses (only six endoscopists performed ≥ 100 colonoscopies). A CQI was constructed for endoscopists performing ≥ 50 colonoscopies during the study (**Fig. e2**, available online), in order to provide an example of how the CQI could be used to compare endoscopists throughout or within hospitals.

The CIR in this study was found to be associated with ASA score and indication for colonoscopy, as well as with bowel preparation and hospital, which are both modifiable factors. Previous studies concluded that not only adequate bowel preparation but also the use of sedation are associated with CIR [9, 12, 22, 23]. One other study found no association between sedation and CIR, and only a nonsignificant ($P = 0.07$) association between bowel preparation and CIR [15]. In the current study, the use of sedatives was not related to the CIR. The general Dutch practice is to perform colonoscopy under conscious sedation, unless the patient prefers not to do so. This may have resulted in confounding by indication. As expected, the study showed that more nonmodifiable factors were associated with ADR than with CIR. Age, sex, and indication for colonoscopy are known to affect the ADR, and adjustment for these factors is required when measuring quality [14, 16, 24, 25]. Hospital, bowel preparation, and cecal intubation were modifiable factors associated with ADR in multivariate analysis. Most previous cohort studies have reported an association between adequate bowel preparation and higher ADR [9, 10, 15, 20, 26]. It seems logical to assume that a higher CIR increases ADR, but not all previous studies have confirmed this [10, 15, 20]. Sedation did not affect ADR and previous studies have shown only limited and largely conflicting evidence on this subject [10, 14, 22, 23].

Table 4 Factors associated with cecal intubation rate.

	Unadjusted OR [95 %CI]	Adjusted OR [95 %CI]
Hospital		
1	2.97 [1.63 – 5.41]	4.92 [2.13 – 11.38]
2	1.59 [0.92 – 2.73]	0.94 [0.50 – 1.77]
3	14.57 [2.01 – 105.64]	16.95 [2.10 – 136.62]
4	4.61 [2.67 – 7.96]	1.86 [0.99 – 3.50]
5	6.00 [3.17 – 11.36]	3.37 [1.57 – 7.26]
6	2.38 [1.44 – 3.93]	1.77 [0.84 – 3.75]
7	Reference	Reference
Type of endoscopist		
Gastroenterologist	Reference	
Fellow	0.90 [0.62 – 1.30]	
Nurse endoscopist	1.22 [0.76 – 1.96]	
Male sex	1.33 [0.96 – 1.84]	1.32 [0.89 – 1.96]
Age, per 10-year increase	0.79 [0.71 – 0.89]	0.92 [0.80 – 1.06]
ASA score		
1	Reference	Reference
2	0.45 [0.32 – 0.64]	0.46 [0.29 – 0.72]
3	0.24 [0.14 – 0.41]	0.48 [0.24 – 0.96]
4	0.03 [0.01 – 0.17]	0.07 [0.01 – 0.72]
Indication		
Anemia / abdominal symptoms	Reference	Reference
Rectal (occult) blood loss	1.84 [0.89 – 3.82]	0.59 [0.22 – 1.55]
Family history of CRC	3.49 [1.42 – 8.62]	0.98 [0.37 – 2.59]
Surveillance	2.29 [1.38 – 3.78]	2.35 [1.32 – 4.20]
Sedation	0.93 [0.40 – 2.14]	
Adequate BBPS	13.36 [9.34 – 19.12]	12.43 [8.09 – 19.12]

OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologist; CRC, colorectal carcinoma; BBPS, Boston Bowel Preparation Scale.

Table 5 Factors associated with adenoma detection rate.

	Unadjusted OR [95 %CI]	Adjusted OR [95 %CI]
Hospital		
1	0.72 [0.54 – 0.95]	0.83 [0.58 – 1.19]
2	0.96 [0.71 – 1.30]	0.95 [0.67 – 1.35]
3	1.67 [1.14 – 2.45]	1.31 [0.83 – 2.07]
4	0.87 [0.70 – 1.08]	0.73 [0.56 – 0.93]
5	0.63 [0.50 – 0.80]	0.55 [0.41 – 0.74]
6	1.04 [0.81 – 1.34]	0.77 [0.56 – 1.04]
7	Reference	Reference
Type of endoscopist		
Gastroenterologist	Reference	Reference
Fellow	1.21 [1.01 – 1.46]	1.12 [0.89 – 1.42]
Nurse endoscopist	1.33 [1.09 – 1.64]	1.27 [0.98 – 1.63]
Male sex	1.78 [1.53 – 2.07]	1.73 [1.47 – 2.05]
Age, per 10-year increase	1.51 [1.43 – 1.61]	1.48 [1.38 – 1.59]
ASA score		
1	Reference	Reference
2	1.75 [1.49 – 2.06]	1.13 [0.93 – 1.37]
3	2.01 [1.44 – 2.79]	1.37 [0.94 – 1.99]
4	1.36 [0.25 – 7.44]	1.86 [0.28 – 12.47]
Indication		
Anemia/abdominal symptoms	Reference	Reference
Rectal (occult) blood loss	1.82 [1.37 – 2.41]	1.63 [1.16 – 2.29]
Family history of CRC	1.14 [0.86 – 1.51]	1.42 [1.02 – 1.97]
Surveillance	2.34 [1.98 – 2.88]	1.70 [1.38 – 2.09]
Sedation	1.26 [0.88 – 1.80]	
Adequate BBPS	1.56 [1.19 – 2.05]	1.84 [1.33 – 2.55]
Cecal intubation	1.81 [1.23 – 2.66]	1.99 [1.24 – 3.20]

OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologist; CRC, colorectal carcinoma; BBPS, Boston Bowel Preparation Scale.

The CQI was developed as a tool to provide incentives for hospitals to improve quality of colonoscopy. It is important to note that the CQI does not reflect absolute quality, as the results are not corrected for case mix. Therefore, it is not fair to consider one hospital to be better than another solely based on a different position in the CQI matrix. Nonetheless, the CQI may help hospitals or individual endoscopists to detect differences compared with other hospitals or endoscopists, prompting them to look into reasons for these differences. If the variation appears to result from differences in procedural or institutional factors, as was shown for bowel preparation, hospitals or endoscopists can focus on this factor to improve quality.

In this context, it is worth mentioning the seemingly outstanding performance of hospital 3 in a limited number of colonoscopies, represented by the small dot in the upper right corner of the CQI matrix (**Fig. 1**). Although multivariate analyses confirmed this performance to be at least partly independent of case mix, it appears that the high rates are importantly affected by differences in baseline characteristics of included patients (**Table e6**, available online). During the study period, significantly more colonoscopies were performed in patients with a positive fecal occult blood test compared with the other hospitals.

Although it seems that there is no linear association between CIR and ADR in the CQI, it is important to emphasize that this conclusion cannot be drawn from the CQI because of the intersection of the *x* and *y* axes at high percentages and the lack of correction for case mix. If the complete CQI was shown (i.e. with *x* and *y* axes ranging from 0 to 100 %), one would see that all dots are in the upper right corner and that an estimation of co-linearity is not possible as all hospitals performed relatively well. The CIR was independently associated with the ADR in the multivariate analysis, but this cannot be directly interpreted from the CQI. It is possible to overcome this by constructing CQIs for a specific indication and age group, for example in screening populations.

The strength of this study is that the prospective registration resulted in reliable data on colonoscopies performed in a representative population of patients visiting academic and nonacademic hospitals. However, limitations of this study should be addressed as well. First, several population characteristics possibly affecting ADR and/or CIR were not known or were incompletely known in this study. Patient co-morbidity, medication use, and smoking status were not recorded. ASA score as an indirect measure for these factors was recorded in all patients. The indications for colonoscopy were consistently reported, but were not highly specific. In particular, more than 60 % of all patients were categorized in a group that included anemia, abdominal symptoms, or change in bowel habit, whereas one might expect this group to be heterogeneous with regard to risk of finding colorectal neoplasms.

Second, some potentially important information on procedural factors was also not available. Endoscopists were aware of the recommendation that withdrawal with mucosal inspection should take at least 6 minutes [3,27,28], but withdrawal time was not recorded in the study. The number of colonoscopies performed in each hospital per year and the experience of each endoscopist were not known, but no significant differences in CIR or ADR were found between different types of endoscopists. This is remarkable, as gastroenterologists are generally more experienced than fellows. A possible explanation is that fellows might have had more time to complete procedures and perform meticulous inspection of the colonic mucosa.

In conclusion, this study investigated the use of CIR and ADR as quality indicators for colonoscopy. The CQI is a simple combination of both indicators for comparison between hospitals. It can provide information to prompt discussion of differences with the aim of improving colonoscopy quality; CIR and ADR can be positively affected by targeting modifiable factors, of which the most important is bowel preparation. Future studies are required to establish whether implementation of competitive feedback in such a comparative way will indeed improve quality of colonoscopy, and what measures are best to improve bowel preparation.

Competing interests: None

Institutions

[1] Department of Gastroenterology and Hepatology, University Medical Center Utrecht, Utrecht, The Netherlands
[2] Department of Gastroenterology and Hepatology, Erasmus Medical Center, Rotterdam, The Netherlands
[3] Department of Gastroenterology and Hepatology, Isala Hospital, Zwolle, The Netherlands
[4] Department of Gastroenterology and Hepatology, Ikazia Hospital, Rotterdam, The Netherlands
[5] Department of Gastroenterology and Hepatology, IJsselland Hospital, Capelle a/d IJssel, The Netherlands
[6] Department of Gastroenterology and Hepatology, Deventer Hospital, Deventer, The Netherlands
[7] Department of Gastroenterology and Hepatology, St. Antonius Hospital, Nieuwegein, The Netherlands
[8] Achmea Health Care, Leiden, The Netherlands
[9] Gupta Strategists, Ophemert, The Netherlands

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Fig. e2 and Table e6

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