Cecal intubation time in screening colonoscopy

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Abstract
The time required to intubate the cecum varies. The aim of this study was to determine whether demographic and anthropometric factors, such as body mass index (BMI), percent body fat, muscle mass, and fat mass, affect the cecal intubation time (CIT) during complete colonoscopy.

A retrospective chart review of 1229 patients (aged 40–80 years) was performed. These patients underwent average-risk screening colonoscopies performed by expert gastroenterologists at Health Check-up Center, Seoul National University Bundang Hospital, during a health check-up. We collected data on age, sex, BMI, percent body fat, muscle mass, fat mass, history of prior abdominal or pelvic surgery, CIT, and bowel preparation quality (Boston Bowel Preparation Scale [BBPS] score).

Of the 1229 patients, 62% were men. The mean age was 55 years, and the mean BMI was 24 kg/m². The median CIT was 5 min. The patients were categorized into two groups according to CIT: easy colonoscopy (CIT ≤ 10 min) and difficult colonoscopy (CIT > 10 min). In univariate analysis, CIT was prolonged by the following factors: older age, poor bowel preparation, lower BMI, lower percent body fat, and less fat mass. Multivariate analysis showed that anthropometric indices including BMI, percent body fat, muscle mass, and fat mass were not significant factors for CIT. Older age (≥ 70 years) (odds ratio [OR]: 2.272, 95% confidence interval [CI]: 1.056–4.890, P = .036) and poor bowel preparation (BBPS score ≤ 5) (OR: 3.817, 95% CI: 1.866–7.808, P = .000) were found to be correlated with difficult colonoscopy.

Our study suggests that anthropometric indices including BMI, percent body fat, muscle mass, and fat mass are not associated with significantly different CIT. Furthermore, sex and prior abdominal or pelvic surgery are not useful factors for a prolonged CIT. Older age (≥ 70 years) and poor bowel preparation (BBPS score ≤ 5) are significant variables predicting the CIT of expert gastroenterologists.

Abbreviations: BBPS = Boston Bowel Preparation Scale, BIA = bioelectrical impedance analysis, BMI = body mass index, CIT = cecal intubation time.

Keywords: anthropometry, cecal intubation time, colonoscopy

1. Introduction
The incidence and mortality of colorectal cancer are rapidly increasing in Korea.\([1]\) Current Korean guidelines recommend screening colonoscopy beginning at age 50 years in the average-risk population.\([2]\) Screening colonoscopy is considered to be one of the strategies for the early detection and prevention of colorectal cancer development from the adenoma-carcinoma pathway.\([3,4]\)

Cecal intubation time (CIT) is defined as the time from the insertion of the colonoscope tip into the anal verge until reaching the cecal base or cecal end.\([5]\) A longer CIT is an indicator of a technically difficult colonoscopy.\([6]\) A prolonged CIT is associated with a higher burden for the colonoscopist (gastroenterologist), colonoscopist fatigue, lower rate of polyp detection, increased pain for the patient, and higher risk of procedure-related complications, leading to a lower quality of colonoscopy.\([7]\)

However, the failure of colonoscopy depends on the colonoscopist’s skill, level of training, and duration or amount of experience. Previous studies have reported that age, sex, body mass index (BMI), bowel preparation quality, and previous surgery are the factors affecting CIT.\([8–11]\) An effective colonoscopy with a shortened CIT is necessary for the early diagnosis of precursor lesions of colorectal cancer such as adenomas or serrated lesions.

The aim of this study was to investigate factors, including anthropometric indices, that are associated with CIT among expert endoscopists.

2. Methods
2.1. Study population
This study analyzed colonoscopies and anthropometric measurements performed at a single tertiary hospital. This retrospective,
cross-sectional study included 1229 subjects aged 40–80 years with an average risk for colorectal cancer, who underwent complete screening colonoscopy from January 2019 to May 2019. Anthropometric data including height, weight, BMI, percent body fat, fat mass, and muscle mass were collected. Weight was measured to the nearest 0.1 kg. Height was measured to the nearest 0.1 cm. Weight was measured using Inbody S-10 (Inbody Co., Ltd., Seoul, Korea), and BMI was calculated as weight in kilograms divided by height in meters squared (kg/m²). All anthropometric results were based on a single-body measurement examination.

A single tertiary hospital, Health Check-up Center, provided various packages of screening examinations including colonoscopy. All screened subjects volunteered or were sponsored by their employer to undergo colonoscopy regardless of age (including asymptomatic subjects in their 20s and 80s who were undergoing a routine health check-up). Subjects with an inflammatory bowel disease requiring current medication and those with a history of colorectal cancer were excluded. This retrospective study was approved by the institutional review board (approval no. B-2006-621-101), which waived the requirement for written informed consent.

2.2. Endoscopic examination

Colonoscopy was conducted in all study subjects by six expert gastroenterologists (> 10 years of endoscopy experience) certified by the Korean Society of Gastrointestinal Endoscopy, using conventional white light videocolonoscopy (CIF-H260 or CIF-H290; Olympus, Aizu, Japan). The score on the Boston Bowel Preparation Scale (BBPS), a 10-point scale assessing bowel preparation after the use of all cleansing agents, was calculated using six different frequencies (1, 5, 50, 250, 500, and 1000kHz) at the following six points of the body to achieve a multisegmental frequency analysis. A total of 30 impedance measurements were obtained using the Biospace device (Model 720, Inbody Co., Ltd.), which calculates BMI body composition using six different frequencies (1, 5, 50, 250, 500, and 1000kHz) at the following six points of the body to achieve a multisegmental frequency analysis. The maximum BBPS score for a perfectly clean colon without any residual liquid was 9 and the minimum BBPS score for an unprepared or failed colon was 0. The BBPS is the most popular validated scoring system.12,13 In our clinical setting, a BBPS score of 6 to 9 indicates good bowel preparation and a BBPS score of 0–5 indicates poor bowel preparation.

2.3. Bioelectrical impedance analysis

A multifrequency bioelectrical impedance analyzer, InBody S5 Biospace device (Model 720, Inbody Co., Ltd.), was used according to the manufacturer’s instructions. Bioelectrical impedance analysis (BIA) estimates body composition using the difference in the conductivity of various tissues given the different biological characteristics of the subjects. Conductivity is proportional to water content, and more specifically for electrolytes, and it decreases as the cell approaches a perfect spherical shape. Adipose tissue is composed of round-shaped cells and contains relatively little water compared with other tissues such as muscle; therefore, conductivity will decrease as body fat increases. In practice, electrodes are placed at six precise tactile points of the body to achieve a multisegmental frequency analysis. A total of 30 impedance measurements were obtained using six different frequencies (1, 5, 50, 250, 500, and 1000kHz) at the following five body segments: right and left arms, trunk, and right and left legs.

2.4. Statistical analysis

Data were analyzed using SPSS software (version 21.0; SPSS Inc., Chicago, IL). Continuous variables are expressed as mean ± standard deviation or median and range of values, or number (percentage), whereas categorical variables are expressed as absolute values and percentages. Pearson’s chi-square test was performed for the statistical comparison of proportions among groups in univariate analysis. Only factors with P values < .05 in univariate analysis were subsequently with odds ratio (ORs) and 95% CI using logistic regression multivariate analysis. All P values were two sided, and P < .05 was considered statistically significant.

3. Results

3.1. Clinical characteristics of the study subjects

This study included 1229 health check-up subjects aged ≥ 40 years who underwent complete screening colonoscopy at a health check-up center of a single tertiary hospital. The mean age of the subjects was 55 ± 9 years, and 62% were men. The prevalence of difficult colonoscopy (CIT > 10 min) in those aged ≥ 40 years was 7%.

Tables 1 and 2 show the differences in demographic and clinical characteristics between subjects with easy colonoscopy and those with difficult colonoscopy. In the univariate analysis, subjects with difficult colonoscopy had a higher likelihood of having old age (P = .028), poor bowel preparation (BBPS score ≤ 5) (P = .000), low BMI (P = .024), low percent body fat (P = .045), and low fat mass (P = .025) than subjects with easy colonoscopy. No significant difference in the risk factors of difficult colonoscopy was found according to sex and muscle mass.

Table 1

Demographics and baseline characteristics of subjects (n = 1229).

| Variables                  | Value          |
|----------------------------|----------------|
| Age (yr)                   | 55.4 ± 8.7     |
| Sex                        |                |
|   Male                     | 743 (61.5)     |
|   Female                   | 465 (38.5)     |
| BMI (kg/m²)                | 24.2 ± 3.2     |
|   < 23                     | 424 (35.1)     |
|   23 ≤, < 25               | 325 (26.9)     |
|   ≥ 25                     | 459 (37.9)     |
| History of prior surgery   | 206 (16.8)     |
|   Abdominal surgery        | 111 (9.1)      |
|   Pelvic surgery           | 95 (7.7)       |
| Quality of bowel preparation|               |
|   BBPS score 6–9           | 1176 (95.7)    |
|   BBPS score 0–5           | 53 (4.3)       |
| Cecal intubation time (min)| 5.0 ± 4.2 (range, 1–51) |
|   Easy, ≤ 10 min           | 1144 (93.2)    |
|   Difficult, > 10 min      | 85 (6.8)       |
| Percent body fat (%)       | 26.9 ± 6.5     |
| Muscle mass (kg)           | 45.5 ± 9.1     |
| Fat mass (kg)              | 18.0 ± 6.1     |

BMI = body mass index, BBPS = Boston Bowel Preparation Scale.

Data are mean ± standard deviation or n (%).
Table 2
Comparison of characteristics between the easy colonoscopy and difficult colonoscopy groups.

|                  | Easy colonoscopy (n=1144) (%) | Difficult colonoscopy (n=85) (%) | P value |
|------------------|-------------------------------|---------------------------------|---------|
| Age (yr)         | 55.3±8.6                      | 57.5±10.4                       | .028*   |
| 40–49            | 317 (27.8)                    | 22 (26.2)                       |         |
| 50–59            | 497 (43.5)                    | 29 (33.3)                       |         |
| 60–69            | 244 (21.4)                    | 22 (26.2)                       |         |
| ≥ 70             | 84 (7.4)                      | 12 (14.3)                       |         |
| Sex              |                               |                                 | .418    |
| Male             | 706 (61.7)                    | 49 (57.1)                       |         |
| Female           | 343 (28.3)                    | 36 (42.9)                       |         |
| Poor bowel preparation | 42 (3.7)            | 11 (13.0)                       | .000*   |
| BMI (kg/m²)      | 24.3±3.2                      | 23.4±3.5                        | .024    |
| < 23             | 393 (33.4)                    | 40 (47.6)                       |         |
| 23 ≤ < 25        | 304 (26.6)                    | 21 (25.0)                       |         |
| ≥ 25             | 447 (39.1)                    | 24 (27.4)                       |         |
| Percent body fat | 27.0±6.4                      | 25.6±7.0                        | .045*   |
| Muscle mass (kg) | 45.5±9.1                      | 44.9±8.6                        | .544    |
| Fat mass (kg)    | 18.2±6.2                      | 16.6±5.8                        | .025    |

BMI=body mass index.
Data are mean± standard deviation or n (%).
Asterisk (*) indicates statistically significant.

3.2. Factors affecting difficult colonoscopy in multiple logistic regression analysis

The results of multiple logistic regression analysis of the association of difficult colonoscopy with components of anthropometric data and bowel preparation are shown in Table 3. Old age (≥ 70 years vs. 40–49 years) was associated with an increased risk for difficult colonoscopy (odds ratio [OR]: 2.272, 95% confidence interval [CI]: 1.056–4.890, P = .037).

Poor bowel preparation (BBPS score ≤ 5) (vs. good bowel preparation: BBPS score 6–9) was associated with an increased risk for difficult colonoscopy (OR: 3.817, 95% CI: 1.866–7.808, P = .000). No significant interactions were found between difficult colonoscopy and the components of anthropometric data, such as low BMI, low percent body fat, and low fat mass.

Table 3
Logistic regression analysis of covariates for cecal intubation time and anthropometric data components.

|                  | Adjusted odds ratio | 95% Confidence interval | P value |
|------------------|---------------------|-------------------------|---------|
| Age              | 1.032               | 0.981–1.020              | .016*   |
| 40–49 yr         | 1                   |                         |         |
| 50–59 yr         | 0.899               | 0.503–1.606              | .719    |
| 60–69 yr         | 1.478               | 0.789–2.769              | .223    |
| ≥ 70 yr          | 2.272               | 1.056–4.890              | .036*   |
| Poor bowel preparation |                  |                          |         |
| Good (BBPS score 6–9) | 1                  |                         |         |
| Poor (BBPS score 0–5) | 3.817             | 1.866–7.808              | .000*   |
| BMI              | 0.927               | 0.770–1.115              | .422    |
| < 23 kg/m²       | 1                   |                         |         |
| 23–25 kg/m²      | 0.898               | 0.382–1.218              | .196    |
| > 25 kg/m²       | 0.489               | 0.324–1.613              | .133    |
| Percent body fat | 0.972               | 0.929–1.018              | .229    |
| Fat mass         | 0.003               | 0.953–1.055              | .907    |

BBPS=Boston Bowel Preparation Scale. BMI=body mass index.
Asterisk (*) indicates statistically significant.

4. Discussion

Previous studies have identified several factors affecting prolonged CIT, including age,[14] sex,[15] BMI,[9,14] fat adipose tissue, waist circumference,[16] diverticulosis,[8] bowel preparation status,[17] and prior abdominal or pelvic surgery[14]; however, these findings remain controversial. Understanding the factors affecting prolonged CIT is meaningful toward complete colonoscopy, as it will allow decreasing the burden on the colonoscopist or the fatigue of procedure, the discomfort of patients, and the risk of complications. Some previous studies tended to show controversial results. One recent meta-analysis study reported older age, female sex, low BMI, and poor bowel preparation as factors significantly associated with a longer CIT.[18] We hypothesized that optimal bowel preparation leads to decreased procedure time (from insertion to withdrawal) and increased polyp detection rate. We found a positive correlation between old age and poor bowel preparation and prolonged CIT. However, when the components of anthropometric data were analyzed, no association with CIT was found for BMI, percent body fat, fat mass, and muscle mass.

The first mechanism for prolonged CIT may be related to an anatomically atypical colon.[19] The anatomic causes of technically difficult colonoscopy are of three types: redundant (dilated) colon; angulated, narrowed sigmoid; or abdominal wall hernia.[18] A redundant colon, which holds an abundant amount of feces or liquids, results in inappropriate bowel preparation and, subsequently, failed or incomplete colonoscopy.

The second mechanism for prolonged CIT may be based on the aging process. In one cohort study in asymptomatic adults, computed tomography colonography revealed that the transverse colon was the major factor affecting colon-length differences according to age,[20] although the total length of the colon in older patients (aged > 60 years) did not differ from that in younger patients. The longer transverse colon in older adults could lead to loop formation during colonoscopy owing to the tortuous and angulated structure. In other study,[21] among aged 75 to 79 years vs. aged 90 years over, the reason for lower completion rates and higher poor bowel preparation showed inactive peristaltic gastrointestinal movements, which could result in inadequate bowel preparation and worsening difficulties with colonoscopy completion. Hypotonic colon in older patients would be recognized as an elongated colon by endoscopists. The anthropometric data in this study, as well as age and bowel preparation status, have a relationship with each other, so these factors may bias the results.

Our results demonstrated that anthropometric data including BMI, percent body fat, fat mass, and muscle mass were not related to prolonged CIT. With respect to the relationship between the amount of abdominal fat or muscle mass and difficult colonoscopy, our assumption was that patients with less intra-abdominal fat or abdominal muscle (thinner patients) might tend to have an angulated sigmoid colon or a transverse colon dipping into the pelvis, leading to a longer CIT. A previous meta-analysis found that a lower BMI is associated with a longer CIT.[18] In contrast, our study did not find any significant association between anthropometric data and prolonged CIT. Therefore, the amount of abdominal fat or muscle did not affect the difficulty of colonoscopy in expert colonoscopists. Results of the present study correspond with the earlier study which reported that less experienced colonoscopists may affect by anthropometric data, as low BMI.[11]
BBPS is a routinely and widely used, well-validated, and reliable method for assessing the colon cleansing status in gastroenterology departments.\(^{[22]}\) Several previous studies have reported an association between BBPS and adenoma detection rate.\(^{[23,24]}\) The adenoma detection rate of the colonoscopist serves as the quality indicator for a screening colonoscopy. Some studies have reported no relationship between endoscopist fatigue and adenoma detection rate.\(^{[25]}\) Theoretically, the less fatigued the endoscopist, the better the quality of the colonoscopy. The technical difficulty of endoscope insertion, subsequently increasing endoscopist fatigue, leads to decreased quality of colonoscopy.

The current study had some strengths. First, this is the first study to investigate the association of anthropometric data including BMI, percent body fat, muscle mass, and fat mass with prolonged CIT. Second, our study used a clearly defined tool for bowel preparation (BBPS). Some significant homogeneity was detected in our analyses of sex and quality of bowel preparation. Third, only highly experienced, qualified endoscopists (excluding any in-training gastroenterologists) performed all screening colonoscopies in a single health check-up center. Our previous study supported that the quality of screening colonoscopies as the adenoma detection rates and also serrated lesion detection rates of each colonoscopist in our health check-up center, published in 2013.\(^{[26]}\) Five expert endoscopists had adenoma detection rate ranges from 20.4% to 30.0%, and also serrated lesion detection rates ranges from 9.7% to 18.8%. Fourth, all study subjects received the same sedatives (midazolam with pethidine) and underwent colonoscopy using the same endoscope types (Olympus CF-H290L or H290L or H260L or Q260L). To enhance the reproducibility of the anthropometric data, one examiner performed two consecutive BBPA measurements.

However, this study had some limitations. First, BBPA, not computed tomography, was used for anthropometric data measurements. Second, we did not evaluate lifestyle factors such as alcohol drinking or smoking status. Third, this is a retrospective chart review which have some recall biases with data collection because researchers cannot control exposure leading to the absence of data on potential confounding factors. Fourth, we used the CIT as cut-off point “10 minutes” dividing easy vs difficult colonoscopy, using “10 minutes” cut-off was based on many other studies references.\(^{[11,27–30]}\)

### 5. Conclusions

This study found that older age (≥ 70 years) and poor bowel preparation (BBPS score ≤ 5) are positively correlated with difficult colonoscopy. However, anthropometric data including BMI, percent body fat, muscle mass, and fat mass are not associated with difficult colonoscopy. The key to overcoming the difficulty of endoscope insertion during colonoscopy is encouraging a proper bowel preparation status in elderly patients.

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### Author contributions

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