

ORIGINAL ARTICLE

BODY MASS INDEX PREDICTS CECAL INSERTION TIME: THE HIGHER, THE BETTER

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Background: It is essential to determine the factors that predict prolonged procedural time during colonoscopy. The aim of this study was to determine the effect of body mass index (BMI) on cecal insertion time (CIT) during colonoscopy.

Methods: Consecutive outpatients who received colonoscopies over a 10 month period (April–October 2007) were enrolled. Exclusion criteria included colonic resection, strictures or exophytic masses precluding colonic evaluation. Data were collected for age, sex, race, height, weight, BMI, waist circumference, prior history of abdominal or pelvic surgery, history of diverticulosis, participation of fellow, CIT, quality of colon cleansing and the amount of sedation used during the procedure.

Results: A total of 1430 patients (586 men and 844 women; mean age 60.3 years) were included in the final analysis. The mean CIT was 648.5 seconds (SE = 11.47). Older age, female gender, fellow involvement, poor bowel preparation and lower BMI were associated with prolonged mean CIT on linear regression analysis ($R^2 = 0.116$; $P < 0.001$). Mean CIT declined linearly with increasing BMI.

Conclusion: A higher BMI is strongly associated with progressively shorter CIT.

Key words: cecal insertion time, colonoscopy, prediction.

Difficult colonoscopy is frequently associated with incomplete colonoscopy, and patient experience with difficult colonoscopy is often described as unpleasant and painful. These patients require more sedation during the procedure. In addition, the length of procedure is usually prolonged in patients who have difficult colonoscopy. Cecal insertion time (CIT), defined as the time taken for insertion of the colonoscope to cecum, is sometimes used as a surrogate measure for difficult colonoscopy.¹ Identification of the factors associated with difficult colonoscopy is important because it could help clinicians anticipate longer procedural times and plan more rational sedation and/or analgesia. Furthermore, scheduling the procedure with an endoscopist with more experience can result in better success rate of complete colonoscopy in difficult-to-complete patient group. Several earlier studies have attempted to identify the factors associated with difficult colonoscopy; they found that factors such as older age, female gender, previous abdominal surgery and lower BMI were associated with a difficult procedure.^{1–3} The objective of this prospective study was to identify factors that can predict CIT.

METHODS

After approval from the institutional review board, a prospective study was performed of consecutive outpatients

undergoing elective outpatient colonoscopies at Henry Ford Hospital (Detroit, MI, USA) in April–October 2007. All the patients enrolled in this study provided written consent before participation. All colonoscopies were performed with a standard video colonoscope. A total of eight attending physicians and eight gastroenterology fellows were involved in the study. Only fellows with at least 1 year of experience in endoscopic procedures were involved in the study. In the procedures with ‘fellow involvement’, the senior fellow would perform the colonoscopy, and the attending would intervene only if the fellow had difficulty completing the procedure. Exclusion criteria included colonic resection, age ≤ 18 years, strictures or exophytic masses precluding colonic evaluation; all other patients were included. Patients were instructed to ingest 4 L polyethylene glycol the night before the procedure. Midazolam with or without fentanyl and/or meperidine was used for sedation during the procedure. The sedation on demand approach was used in administering these agents. CIT was recorded by the endoscopy nurse assisting the procedure. Patients who had an incomplete colonoscopy, defined as inability to reach the base of cecum, were excluded from the final analysis. Demographic data (age, sex, race), height, weight, body mass index (BMI), waist circumference, prior history of abdominal or pelvic surgery, history of diverticulosis and participation of fellow were recorded by the nurses before the procedure in the colonoscopy preparation suite. Patients were divided into five categories based on their BMI: Underweight (BMI < 19), Normal (BMI 19–25), Overweight (BMI > 25–30), Obese (BMI > 30–40), Morbidly Obese (BMI > 40). Abdominal circumference was measured at the mid-level between the last

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rib and the iliac crest. Data on CIT, quality of colon cleansing and the amount of sedation used during the procedure were recorded immediately after the end of procedure. The quality of bowel cleansing was graded as good (i.e. no clear liquid or a small amount), fair (i.e. a large amount of clear liquid or a small amount of semi-solid stools) or poor (i.e. a significant amount of semi-solid stools).

Statistical analysis

Non-parametric data analysis was performed using Mann-Whitney and Kruskal-Wallis tests to compare variables between two groups and three or more groups, respectively. Correlation between variables was tested with Spearman's rank correlation coefficient. Age- and sex-adjusted linear regression analysis was performed to identify factors associated with CIT. All analyses were performed with SPSS v. 17.0 (SPSS Inc., Chicago, IL, USA), and $P < 0.05$ was considered statistically significant.

RESULTS

A total of 1808 outpatient colonoscopies were performed between April 2007 and October 2007. Among these, 1430 patients fulfilled the criteria for analysis, including 586 men and 844 women. The attending colonoscopists in this study had performed a mean of >500 colonoscopies during the prior year. The majority of the patients in this study were African-

American (77%) and the mean patient age was 60.3 years (range, 21–92 years). The endoscopist-assessed quality of bowel cleansing was poor in 41 patients (2.9%) and fair in 79 (5.5%). Prior history of abdominal or pelvic surgery was present in 535 patients (37.4%). The mean \pm SE CIT was 648.5 ± 11.5 s, which was significantly more prolonged in women than in men ($P < 0.001$) (Table 1). The mean CIT of procedures with fellow involvement were prolonged compared to those performed by attending colonoscopists alone ($P < 0.001$). Mean CIT declined linearly with increasing BMI (Table 1). Race, previous history of abdominal or pelvic surgery, and diverticulosis had no association with CIT. Linear regression analysis was performed with the variables for which $P < 0.2$ in univariate analysis. The overall regression model was significant, with adjusted $R^2 = 0.105$ ($P < 0.0001$). The final model of regression analysis revealed that older age, female gender, fellow involvement, poor bowel preparation and lower BMI were associated with longer CIT (Table 2). No correlation was noted between CIT and history of diverticulosis, prior history of abdominal or pelvic surgery, and race. Poor quality of bowel preparation showed a trend towards prolonged CIT in both univariate and linear regression analysis.

Sedative agents used in our study included midazolam (in 89.8%), fentanyl (12%) and mepiridine (89.9%). No association was noted between the amount of the sedative agent used and BMI category. However, a positive correlation was noted with CIT and sedation dose (midazolam: $r = 0.30$,

Table 1. Univariate analysis of predictors of cecal insertion time (CIT)

	<i>n</i> (%)	CIT, mean \pm SE (s)	Mean rank	<i>P</i> -value
Total	1430 (100.0)	648.5 \pm 11.5		
Age				
<65 years	993 (69.0)	621 \pm 12.5	694	0.004
>65 years	455 (31.0)	708 \pm 22.4	451	
Sex				
Men	586 (41.0)	604 \pm 17.6	655	<0.0001
Women	844 (59.0)	679 \pm 14.3	757	
Race				
African American	1108 (77.5)	647 \pm 12.5	713	0.87
Caucasian	272 (19)	655 \pm 27.0	717	
Other	50 (3.5)	644 \pm 49.5	743	
Diverticulosis				
Present	463 (32.4)	675 \pm 21.1	732	0.271
Absent	967 (67.6)	635 \pm 13.0	706	
Prior abdominal surgery				
Present	535 (37.4)	669 \pm 19.4	722	0.642
Absent	895 (62.6)	636 \pm 13.5	711	
Involvement of fellow				
Yes	633 (44.3)	545 \pm 12.3	852	<0.0001
No	797 (55.7)	779 \pm 18.6	606	
Quality of bowel prep				
Good	1310 (91.6)	643 \pm 11.6	708	0.06
Fair	79 (5.5)	694 \pm 48.5	764	
Poor	41 (2.9)	741 \pm 64.3	843	
Body mass index				
Underweight (<19)	40 (2.8)	743 \pm 66.5	835	0.036
Normal (19–25)	121 (8.5)	703 \pm 27.4	764	
Overweight (>25–30)	624 (43.6)	633 \pm 18.6	706	
Obese (>30–40)	522 (36.5)	630 \pm 18.0	693	
Morbidly obese (>40)	123 (8.6)	623 \pm 38.5	684	

Table 2. Linear regression model of predictors of cecal insertion time

	β	SE	95%CI for β		<i>P</i> -value
			Lower	Upper	
Age	4.35	0.92	2.55	6.15	0.034
Sex	82.96	22.09	39.61	126.29	<0.0001
Quality of preparation	57.29	26.92	4.47	110.10	0.034
Fellow involvement	237.03	21.30	192.25	278.81	<0.0001
Body mass index	-3.48	1.56	-6.58	-0.421	0.026
Prior abdominal surgery	-1.67	22.36	-45.54	42.20	0.94

Regression analysis: $F = 27.84$; degree of freedom = 6, $P < 0.0001$.
CI, confidence interval.

Table 3. Amount of sedation used during procedures with fellow involvement and attending

	Fellow (mean rank)	Attending (mean rank)	<i>P</i> -value
Meperidine	664.1	642.1	0.264
Fentanyl	97.7	76.5	0.005
Midazolam	718.9	598.7	<0.0001

$P < 0.0001$; fentanyl: $r = 0.32$, $P < 0.0001$; meperidine: $r = 0.11$, $P < 0.0001$). We performed a subanalysis for the amount of sedation and analgesics used in the procedures performed by attending and those where a fellow was involved. The amount of midazolam and fentanyl was significantly higher in the procedures with fellow involvement (Table 3).

DISCUSSION

Several studies have attempted to identify the factors associated with difficult colonoscopy. The association of lower BMI with incomplete colonoscopy and longer CIT has been observed in some of the earlier prospective and retrospective studies.^{1,2,4} Our study revealed several interesting findings. One of the main observations was the strong correlation noted between BMI and CIT (Table 1). This finding is believed to be the result of better colon support by the visceral fat, which minimizes loop formation during colonoscopy. Khashab *et al.* observed that overweight patients have shorter colons compared to those with normal BMI.⁵ The difference in the total colon length could also be a contributing factor for shorter CIT in obese patients.

In our study, older age was associated with longer CIT according to both univariate and linear regression analysis. This agrees with some of the earlier studies.¹⁻³ The likely reason for this finding is that colonic elasticity decreases with age, which could predispose some patients to loop formation.

Female gender was associated with prolonged CIT in our study, which is consistent with several earlier studies.^{1,2,4} The distribution of fat in women is predominantly in the gluteal region and less in the viscera compared to men.⁶ Therefore, there is decreased colon support in women compared to men. In addition, women have been shown to have longer colons

than men, making women more predisposed to loop formation. Gender-based differences in CIT could also be explained by the increased abdominal wall musculature in men, which may provide more external resistance and act as an external splint to the colonoscope, preventing loop formation.⁷

In our study, fellow involvement was significantly associated with prolonged CIT both in univariate and regression analysis ($P < 0.0001$). Similar results were obtained in a few earlier studies.^{2,8} This can be easily explained by the learning-curve phenomenon for trainees performing the procedure.⁹ In addition, higher sedation and analgesic use was associated with procedures involving fellows. The amount of midazolam and fentanyl was significantly higher in the procedures involving fellows (Table 3). This observation highlights the importance of better skills, which can minimize the need for sedation during colonoscopy that, in turn, minimizes adverse events related to the procedure.¹⁰

Poor quality of bowel preparation showed a trend towards prolonged CIT. This contrasts with some earlier studies that demonstrated that poor bowel preparation influences the insertion time.¹¹ However, the findings from our study should be interpreted with caution because the sample size of patients with poor or fair bowel preparation was very small.

Prior history of abdominal or pelvic surgery has been associated with difficult colonoscopy in several earlier studies.^{12,13} There was no association between the history of abdominal or pelvic surgery and CIT in our study, which is similar to few other studies.^{1,4} The reason for this discrepancy could be that the type of surgery was not specified during data collection. Pelvic surgeries, especially hysterectomies, are associated with difficult colonoscopy relative to other abdominal surgeries.

The strength of this study is its prospective design and large sample size. However, there were some limitations. It was a single-center study and some clinical practices may differ from those used in other studies. Additionally, factors such as pain tolerance, which may be important to difficult colonoscopy, could not be assessed. However, the majority of procedures were performed with the patient under sedation and the administration of intravenous analgesia during the procedure. Therefore, we believe that it did not likely confound our results.

In summary, this prospective study on outpatient colonoscopy patients demonstrated that increasing BMI is associated with progressively decreasing CIT. In addition, older age, female gender and fellow involvement were associated with prolonged CIT.

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