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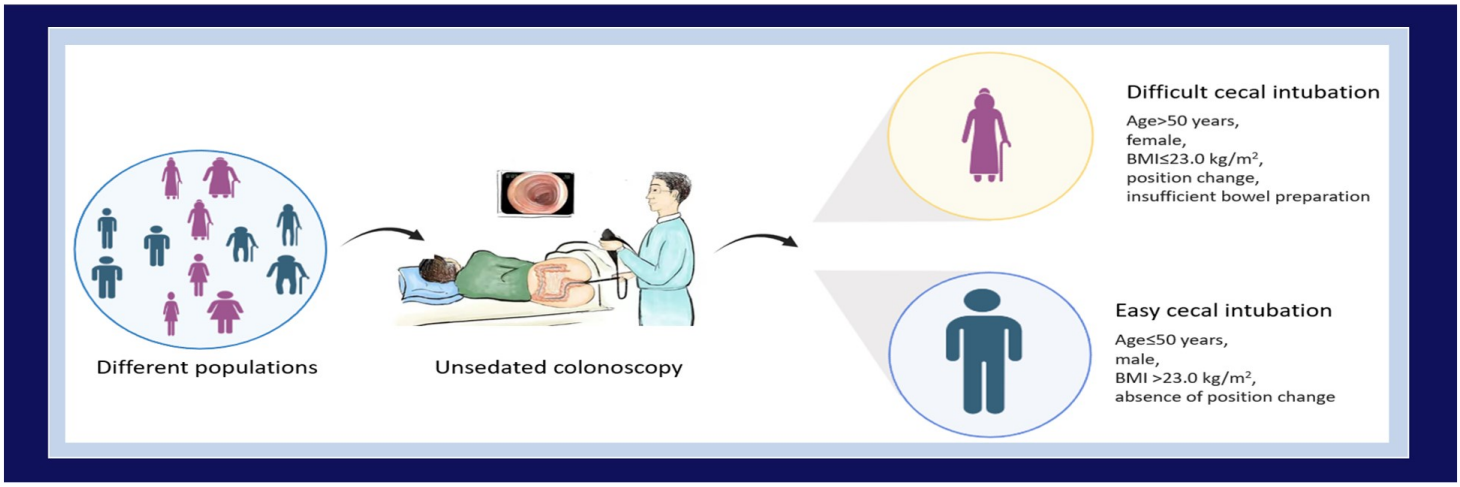

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Factors of easy and difficult cecal intubation during unsedated colonoscopy

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Data availability statement: the datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Informed consent statement: due to the retrospective nature of the study, the requirement for written informed consent was waived.

ABSTRACT

Background and aims: difficulty of cecal intubation should be a main indicator for the need of sedated colonoscopy and skilled endoscopists. The present study aimed to explore the factors associated with easy and difficult cecal intubation in unsedated colonoscopy.

Methods: all consecutive patients who underwent unsedated colonoscopy at our department by the same endoscopist from December 3, 2020 to August 30, 2022 were retrospectively collected. Age, gender, body mass index (BMI), reasons for colonoscopy, position change, Boston Bowel Preparation Scale score, cecal intubation time (CIT) and major colonoscopic findings were analyzed. CIT < 5 min, CIT 5-10 min and CIT > 10 min or failed cecal intubation were defined as easy, moderate and difficult cecal intubation, respectively. Logistic regression analyses were performed to identify independent factors associated with easy and difficult cecal intubation.

Results: overall, 1,281 patients were included. The proportions of easy and difficult cecal intubation were 29.2 % (374/1,281) and 27.2 % (349/1,281), respectively. Multivariate logistic regression analysis found that age ≤ 50 years, male, BMI > 23.0 kg/m^2 and the absence of position change were independently associated with easy cecal intubation, and that age > 50 years, female, BMI ≤ 23.0 kg/m^2, position change, and insufficient bowel preparation were independently associated with difficult cecal intubation.

Conclusions: some convenient factors independently associated with easy and difficult cecal intubation have been identified, which will be potentially helpful to determine whether a colonoscopy should be sedated and a skilled endoscopist

should be selected. The current findings should be further validated in large-scale prospective studies.

Keywords: Cecal intubation. Factors. Colonoscopy.

Introduction

Colorectal cancer is the third most common cancer worldwide and the fourth leading cause of cancer death (1). Colonoscopy is the gold standard approach for colorectal cancer screening (2,3). Notably, during colonoscopy, successful cecal intubation is necessary to avoid missed lesions, especially in the terminal ileum and proximal colon (4). In addition, rapid cecal intubation is crucial to shorten the duration of overall colonoscopy and decrease the risk of abdominal pain, abdominal distension and anal discomfort, and even perforation (5).

Previous studies reported that age, gender, body mass index (BMI), constipation, bowel preparation quality and history of abdominal surgery were associated with cecal intubation time (CIT) (6-13). However, the study design greatly varied among them. First, the type of colonoscopy was heterogeneous among previous studies. Sedated colonoscopy was performed in some studies, but unsedated colonoscopy in others. More importantly, the factors associated with difficult cecal intubation may be different between sedated and unsedated colonoscopy (6,8,9,14). Second, the criteria for assessing bowel preparation quality were inconsistent among previous studies. Some of them only subjectively and arbitrarily assessed bowel preparation quality (i.e., poor, fair, and good) (6-9,13), but others employed well-validated criteria for bowel preparation quality, such as Ottawa and Boston bowel preparation scales. Third, the characteristics of included patients were heterogeneous among previous studies. Some of them included patients with a history of colorectal resection, which potentially facilitates cecal intubation procedure (6,8).

At present, it seems that sedated colonoscopy is preferred and more accepted, but requires an anesthesiologist, has a high cost, and carries a risk of anesthesia (i.e., allergy and aspiration pneumonia), despite all this, there is a good patient compliance (15). Additionally, some patients would have easy cecal intubation

without any significant complaints during unsedated colonoscopy. In fact, these patients do not require sedated colonoscopy. In this setting, it is necessary to explore who will have easy cecal intubation. However, to the best of our knowledge, few studies have evaluated the factors associated with easy cecal intubation in unsedated colonoscopy.

Herein, we report a retrospective observational study to explore the factors associated with easy and difficult cecal intubation during unsedated colonoscopy.

MATERIALS AND METHODS

Study design

In this study, the medical records of 1,537 consecutive patients who underwent unsedated colonoscopy by an endoscopist (XQ) at the Department of Gastroenterology from December 3, 2020 to August 30, 2022 were retrospectively reviewed. This endoscopist had completed a total of 468 colonoscopies before the enrollment period. The exclusion criteria were as follows: a) CIT was influenced by the problems of endoscopic equipment; b) endoscopic polypectomy and/or biopsy performed during cecal intubation process; c) cecal intubation was influenced by the presence of colonic space-occupying lesion and/or intestinal stenosis; d) patients with a history of colonic resection; e) colonoscopy was not independently completed by the endoscopist; and f) CIT data was lacking. The study protocol was reviewed and approved by the Medical Ethical Committee of the General Hospital of Northern Theater Command. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki.

Data collection

The following data were collected: gender, age, height, weight, outpatient or inpatient, colonoscopy performed in the morning, history of abdominal surgery and colonoscopy, reasons for colonoscopy, position change, major colonoscopic findings (i.e., colonic diverticulosis, colitis, and polyp/adenoma), success of cecal intubation and CIT. Boston Bowel Preparation Scale (BBPS) score (16) and BMI were calculated.

Definitions

According to the World Health Organization classification for Asian populations, patients were defined as underweight (BMI < 18.5 kg/m^2), normal weight (18.5 ≤ BMI ≤ 23.0 kg/m^2) and overweight/obese (BMI > 23.0 kg/m^2) (17). CIT was defined as the time from the anus to ileocecal valve, appendiceal orifice or terminal ileum by the colonoscope. According to the definitions of difficult colonoscopy in most previous studies and the experiences of endoscopists (8,14), CIT < 5 min, CIT 5-10 min and CIT > 10 min or failed cecal intubation were defined as easy, moderate, and difficult cecal intubation, respectively. Sufficient bowel preparation was defined as total BBPS score of ≥ 6 with a BBPS score of ≥ 2 per colon segment (18).

Bowel preparation and colonoscopy

Patients were informed of semi-liquid and non-slag diet for breakfast and lunch and full-liquid diet for dinner on the day before colonoscopy, and be fasting on the day of colonoscopy. All patients used a modified protocol of bowel preparation by 3 L polyethylene glycol (PEG) 4000: 1 L PEG-4000 is taken in the evening before colonoscopy, and 2 L PEG-4000 and 30 ml simethicone are taken in the morning of colonoscopy. During unsedated colonoscopy, lidocaine hydrochloride gel was used on the anus. Colonoscopy was started from the patient's left lateral decubitus position, and position changes mainly included supine, right and prone positions at the endoscopist's discretion. The Fujinon colonoscope (EC-530WM, EC-450WI5, or EC-250WM5, Japan) was used, and only air was insufflated during colonoscopy.

Statistical analyses

Demographics, clinical characteristics and endoscopic findings were compared between groups. Continuous variables were expressed as the median (range). Categorical variables were expressed as frequency (percentage). Logistic regression analyses were performed to identify the independent factors associated with easy and difficult cecal intubation. Only variables that were statistically significant in the univariate analyses were further included in multivariate analyses. Odds ratios (ORs) with 95 % confidence intervals (CIs) were calculated. A two-tailed $p < 0.05$ was

considered statistically significant. All statistical analyses were performed by using IBM SPSS software version 20.0 (IBM Corp, Armonk, New York, USA).

RESULTS

Patient characteristics

Overall, 1,281 patients were included (Fig. 1). The characteristics of patients are described in table 1. The median age was 51.86 years (range: 17-94) and 46.2 % (592/1,281) were female. The median BMI was 24.20 (range: 14.7-38.9) kg/m^2. The rate of cecum intubation was 98.8 % (1,266/1,281). No major complications developed in all patients. The mean CIT was 8.12 ± 5.07 min, and the proportion of easy, moderate, and difficult cecal intubation were 29.2 % (374/1,281), 43.6 % (558/1,281), and 27.2 % (349/1,281), respectively. The rate of insufficient bowel preparation was 9.6 % (121/1,264).

Factors associated with easy cecal intubation

Univariate logistic regression analyses demonstrated that age, gender, BMI, history of abdominal surgery, difficult defecation, formless stool and position change were significantly associated with easy cecal intubation. Multivariate logistic regression analyses showed that age ≤ 50 years, male, BMI > 23.0 kg/m^2 and absence of position change remained independently associated with a higher probability of easy cecal intubation (Table 2).

Factors associated with difficult cecal intubation

Univariate logistic regression analyses demonstrated that age, gender, BMI, history of abdominal surgery, difficult defecation, formless stool, screening/surveillance, position change and insufficient bowel preparation were significantly associated with difficult cecal intubation. Multivariate logistic regression analyses showed that age > 50 years, female, BMI ≤ 23.0 kg/m^2, position change and insufficient bowel preparation remained independently associated with a higher probability of difficult cecal intubation (Table 3).

DISCUSSION

Our study demonstrated that age ≤ 50 years, male sex, BMI > 23.0 kg/m^2 and absence of position change were independently associated with easy cecal intubation, and that age > 50 years, female, BMI ≤ 23.0 kg/m^2, insufficient bowel preparation and position change were independently associated with difficult cecal intubation. The association of these above-mentioned variables with difficulty of cecal intubation can be explained as follows. First, older, female and thinner patients have a longer colon, especially transverse colon (19). A longer colon is more likely to bend and angulate in the abdominal cavity, which makes it easier to form loops during colonoscopy (19-21). In detail, older patients often have more loose mesenteries, which fix the colon less sufficiently and then may increase the risk of loop formation during colonoscopy. Furthermore, women often have a deeper and rounder pelvic cavity, in which a long transverse colon is easier to dip into pelvic cavity, thereby causing a more curved transverse colon and a more acute angle of splenic and liver flexures (10,22). Second, the distribution of body fat is different between males and females. Male fat is mainly located at the abdomen, whereas female fat is mainly located at the hips and thighs (23,24). Female and thinner patients have less abdominal fat content, which causes a poor support for the colon, especially sigmoid, and makes the colonic angle sharper (8,25). Third, there is often a sharp angle mainly at the sigmoid colon, splenic flexure and liver flexure. Position change can make colonic angle less sharp and a curved colon straighter to facilitate the passage of a colonoscope. More frequent position changes will take a longer CIT (24). In our study, 912 patients had at least one position change during cecal intubation process, and 18.1 % (165/912) had at least two position changes, of whom none had CIT < 5 min and only 30 had CIT < 10 min. Fourth, insufficient bowel preparation is mainly manifested as excessive retention of residual stools in the colon, which can affect the visual field of colonoscopy (24). This requires endoscopists to spend more time cleansing the colon to find a way forward and observe lesions (26). Notably, bowel preparation quality is independently associated with difficult cecal intubation, but not easy cecal intubation. This may be due to the fact that the anatomical structure of the colon in the abdominal cavity, which is

regarded as the most important indicator for easy cecal intubation, is not influenced by bowel preparation quality (6).

Some previous studies found that the history of abdominal surgery, especially hysterectomy, was independently associated with difficult cecal intubation. This may be because abdominal surgery can lead to colonic adhesions, which may make it difficult for the colonoscope to pass through (13). However, in our study, the history of abdominal surgery was not independently associated with difficult cecal intubation. There are some possible explanations as follows. First, the type of abdominal surgery may be heterogeneous among participants undergoing colonoscopy. In our study, abdominal surgery was laparoscopic in some patients, but open in others. By comparison, in some previous studies, the type of surgery was not specified (6,8). During laparoscopic surgery, only a few holes are required in the abdomen, which has a lower risk of adhesion (27) and does not greatly influence the difficulty of cecal intubation. Second, the definition of difficult colonoscopy and exclusion criteria are different between current and previous studies. Some previous studies defined difficult colonoscopy as CIT > 15 min and/or excluded patients with failed cecal intubation, which was inconsistent with our study (9,13,28). In this setting, the statistical results regarding the association of difficult colonoscopy with abdominal surgery might be different among studies.

Our study has several major features. First, all patients underwent unsedated colonoscopy independently by an endoscopist using the same colonoscope. Second, our study used BBPS to evaluate bowel preparation quality. Third, all relevant data were prospectively recorded, which can ensure data completeness. Fourth, cecal intubation was classified as easy, moderate and difficult according to the CIT. Independent risk factors of easy and difficult cecal intubation were calculated to identify the patients who are easy or difficult to complete colonoscopy, respectively. Finally, as far as we know, there is no previous study on the factors of easy colonoscopy.

A limitation of our study was that the levels of patients' pain tolerance and anxiety before colonoscopy and during cecal intubation process were not evaluated. Discomfort may adversely affect CIT and colonoscopy completion. Patients with

emotional processing difficulties may also be more likely to have anxiety, which can increase pain during colonoscopy and influence patient's colonoscopy experiences (29). Sedated colonoscopy seems to be more appropriate for such patients (30-32). Additionally, the age of the colonoscopes used in the current study was old, with limited spiral rotation and insensitive buttons, which potentially prolonged CIT.

In conclusion, we have identified several independent risk factors of easy and difficult cecal intubation, which should be potentially helpful for guiding the selection of sedation for colonoscopy, but the current findings should be further validated.

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Table 1. Characteristics of study population

Variables	*No. Pts.*	*Median (range) or frequency (percentage)*
Age (years)	1,281	54.00 (17-94)
Female (%)	1,281	592 (46.2 %)
BMI (kg/m^2)	1,281	24.20 (14.7-38.9)
BMI < 18.5 kg/m^2 (%)	1,281	59 (4.6 %)
BMI 18.5-23.0 kg/m^2 (%)	1,281	448 (35.0 %)
BMI > 23.0 kg/m^2 (%)	1,281	774 (60.4 %)
Reasons for colonoscopy		
Screening/surveillance (%)	1,239	227 (18.3 %)
Difficult defecation (%)	1,239	166 (13.4 %)
Formless stool (%)	1,239	608 (49.1 %)
Abdominal discomfort (%)	1,239	472 (38.1 %)
Outpatient (%)	1,281	890 (69.5 %)
History of abdominal surgery (%)	1,280	346 (27.0 %)
History of colonoscopy (%)	1,281	638 (49.8 %)
Colonoscopy performed in the morning (%)	1,281	752 (58.7 %)
Position changes (%)	1,215	912 (75.1 %)
Total BBPS score	1,264	7 (1-9)
Insufficient bowel preparation (%)	1,264	121 (9.6 %)
Cecal intubation rate (%)	721	713 (98.9 %)
CIT (min)	1,266	6.58 (1.28-40.58)
CIT < 5 min (%)	1,281	374 (29.2 %)
CIT 5-10 min (%)	1,281	558 (43.6 %)
CIT > 10 min (%)	1,281	349 (27.2 %)
Major colonoscopic findings		
Colon diverticulosis (%)	1266	162 (12.8 %)
Colitis (%)	1266	362 (28.6 %)

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Colon polyp/adenoma (%)	1,270	837 (65.9 %)

BMI: body mass index; CIT: cecal intubation time; No. Pts.: number of patients; BBPS: Boston Bowel Preparation Scale.

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Table 2. Logistic regression analyses of factors associated with easy cecal intubation

Variables	*Univariate analysis*			*Multivariate analysis*		
	OR	*95 % CI*	*p value*	*OR*	*95 % CI*	*p value*
Age > 50 years *versus* age ≤ 50 years	0.433	0.339-0.554	*< 0.001*	0.515	0.386-0.688	*< 0.001*
Female versus male	0.337	0.259-0.437	*< 0.001*	0.479	0.350-0.654	*< 0.001*
BMI > 23.0 kg/m^2 *versus* BMI ≤ 23.0 kg/m^2	2.490	1.905-3.255	*< 0.001*	2.313	1.701-3.145	*< 0.001*
Outpatient *versus* inpatient	0.985	0.759-1.279	0.910			
Colonoscopy performed in the morning *versus* afternoon	0.961	0.753-1.227	0.750			
History of abdominal surgery (yes *versus* no)	0.578	0.432-0.773	*< 0.001*	0.807	0.572-1.138	0.220
History of colonoscopy (yes *versus* no)	1.141	0.897-1.452	0.283			
Difficult defecation (yes *versus* no)	0.456	0.300-0.695	*< 0.001*	0.665	0.409-1.081	0.100
Formless stool (yes *versus* no)	1.864	1.455-2.387	*< 0.001*	1.289	0.960-1.732	0.092
Abdominal discomfort (yes *versus* no)	0.912	0.709-1.174	0.476			
Screening/surveillance (yes *versus* no)	0.774	0.558-1.073	0.124			
Position change (yes *versus* no)	0.175	0.132-0.232	*< 0.001*	0.166	0.122-0.225	*< 0.001*
Insufficient bowel preparation (yes *versus* no)	0.729	0.471-1.128	0.156			
Colon diverticulosis (yes *versus* no)	1.111	0.778-1.586	0.562			
Colitis (yes *versus* no)	1.224	0.941-1.593	0.132			
Colon polyp/adenoma (yes *versus* no)	0.868	0.674-1.117	0.271			

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Table 3. Logistic regression analyses of factors associated with difficult cecal intubation

Variables	*Univariate analysis*			*Multivariate analysis*		
	OR	*95 % CI*	*p value*	*OR*	*95 % CI*	*p value*
Age > 50 years *versus* age ≤ 50 years	1.932	1.485-2.514	*< 0.001*	1.646	1.215-2.230	0.001
Female *versus* male	1.973	1.537-2.532	*< 0.001*	1.629	1.206-2.199	0.001
BMI > 23.0 kg/m^2 *versus* BMI ≤ 23.0 kg/m^2	0.550	0.429-0.706	*< 0.001*	0.603	0.454-0.802	< 0.001
Outpatient *versus* inpatient	1.174	0.895-1.540	0.246			
Colonoscopy performed in the morning *versus* afternoon	0.909	0.709-1.166	0.454			
History of abdominal surgery (yes *versus* no)	1.517	1.161-1.984	*0.002*	1.263	0.925-1.724	0.141
History of colonoscopy (yes *versus* no)	0.870	0.680-1.113	0.269			
Difficult defecation (yes *versus* no)	1.828	1.298-2.575	*0.001*	1.421	0.917-2.202	0.115
Formless stool (yes *versus* no)	0.549	0.424-0.709	*< 0.001*	0.836	0.587-1.191	0.322
Abdominal discomfort (yes *versus* no)	0.958	0.739-1.241	0.744			
Screening/surveillance (yes *versus* no)	1.378	1.009-1.883	*0.044*	1.324	0.866-2.026	0.195
Position changes (yes *versus* no)	9.984	5.837-17.078	*< 0.001*	10.133	5.767-17.806	*< 0.001*
Insufficient bowel preparation (yes *versus* no)	2.130	1.488-3.133	*< 0.001*	2.306	1.457-3.651	*< 0.001*
Colon diverticulosis (yes *versus* no)	0.938	0.642-1.369	0.740			
Colitis (yes *versus* no)	0.895	0.676-1.184	0.437			
Colon polyp/adenoma (yes *versus* no)	1.274	0.975-1.666	0.077			

OR: odds ratio; CI: confidence interval; BMI: body mass index.

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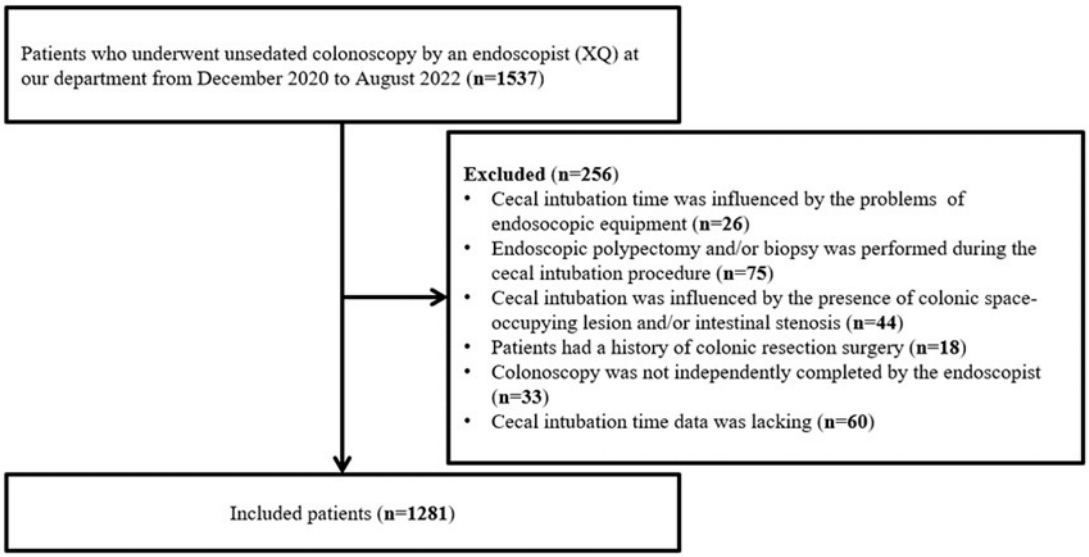

Fig. 1. Flowchart of patients' enrollment.