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ORIGINAL ARTICLE

Retrospective Study

When and why a colonoscopist should discontinue colonoscopy by himself?

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Abstract

AIM: To investigate when and why a colonoscopist should discontinue incomplete colonoscopy by himself.

METHODS: In this cross-sectional study, 517 difficult colonoscope insertions (Grade C, Kudo's difficulty classification) screened from 37800 colonoscopy insertions were collected from April 2004 to June 2014 by three 4th-level (Kudo's classification) colonoscopists. The following common factors for the incomplete insertion were excluded: structural obstruction of the colon or rectum, insufficient colon cleansing, discontinuation due to patient's discomfort or pain, severe colon disease with a perforation risk (*e.g.*, severe ischemic colonopathy). All the excluded patients were re-scheduled if permission was obtained from the patients whose intubation had failed. If the repeat intubations were still a failure because of the difficult operative techniques, those patients were also included in this study. The patient's age, sex, anesthesia and colonoscope type were recorded before colonoscopy. During the colonoscopic examination, the influencing factors of fixation, tortuosity, laxity and redundancy of the colon were assessed, and the insertion time (> 10 min or ⩽ 10 min) were registered. The insertion time was analyzed by *t*-test, and other factors were analyzed by univariate and multivariate logistic regression.

RESULTS: Three hundred and twenty-two (62.3%) of the 517 insertions were complete in the colonoscope insertion into the ileocecum, but 195 (37.7%) failed in the insertion. Fixation, tortuosity, laxity or redundancy occurred during the colonoscopic examination. Multivariate logistic regression analysis revealed that fixation (OR = 0.06, 95%CI: 0.03-0.16, $P < 0.001$) and tortuosity (OR = 0.04, 95%CI: 0.02-0.08, $P < 0.001$) were significantly related to the insertion into the ileocecum in the left hemicolon; multivariate logistic regression analysis also revealed that fixation (OR = 0.16, 95%CI: 0.06-0.39, $P < 0.001$), tortuosity (OR

0.23, 95%CI: 0.13-0.43, $P < 0.001$), redundancy (OR = 0.12, 95%CI: 0.05-0.26, $P < 0.001$) and sex (OR = 0.35, 95%CI: 0.20-0.63, $P < 0.001$) were significantly related to the insertion into the ileocecum in the right hemicolon. Prolonged insertion time (> 10 min) was an unfavorable factor for the insertion into the ileocecum.

CONCLUSION: Colonoscopy should be discontinued if freedom of the colonoscope body's insertion and rotation is completely lost, and the insertion time is prolonged over 30 min.

Key words: Colonoscopy; Colonoscope insertion; Insertion technique

Core tip: This original article investigated when and why a colonoscopist should discontinue incomplete colonoscopy by himself. If freedom of the colonoscope body's insertion and rotation is lost because of unfavorable factors, such as fixation, tortuosity, laxity, and redundancy occurring in the colon, and the insertion time is prolonged > 30 min after repeated attempts by the 4th-level colonoscopists, we suggest the colonoscopy should be discontinued by the colonoscopist.

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INTRODUCTION

Because of the advances of colonoscopic techniques[1,2] and the improvements in the design and construction of the colonoscope[3,4], colonoscopy has not been a difficult procedure for most colonoscopists; even the colonoscope insertion into the ileocecum has not been as tough a task as it used to be. However, there are still some difficulties in the insertion of the colonoscope. According to the reports in the medical literature, some factors caused incomplete colonoscopy, *e.g.*, the patient's age, sex, obesity, preoperative bowel preparation, previous abdominal surgery, and constipation[5-7]. But all these factors can only roughly predict that these patients are difficult to intubate to the ileocecum, and even highly-skilled 4th-level colonoscopists (Kudo's classification[3], Table 1) were unable to guarantee a 100% success rate when ileocecal intubation was performed. Therefore, to determine when and understand why this kind of colonoscopic intubation should be discontinued is very important to colonoscopists. The present study was designed to investigate this problem.

MATERIALS AND METHODS

From April 2004 to June 2014, a total of 37800 colonoscope insertions were performed by three 4th-level expert colonoscopists at our endoscopic center, who had performed > 10000 on average and whose completion rate of the insertion into the ileocecum was 95%-98%. In order to explore the extraordinary factors for incomplete colonoscope insertion into the ileocecum, we excluded the following commonly-encountered factors for incomplete colonoscope insertion into the ileocecum: structural obstruction of the colon or the rectum; insufficient colon cleansing; discontinuation due to patient's discomfort or pain; severe colon disease with a perforation risk (*e.g.*, severe ischemic colonopathy). All the excluded patients were re-scheduled if permission was obtained from the patients whose intubation had failed. If the repeat intubations were still a failure because of the difficult operative techniques, those patients were also included in this study. Thus, 517 patients were included, who underwent the most difficult colonoscopic procedures (Grade C, Kudo's difficulty classification[3], Table 2) by three 4th-level expert colonoscopists. Of the 517 patients, 322 (62.3%) completed the colonoscope insertion into the ileocecum, but 195 (37.7%) had incomplete colonoscope insertion into the ileocecum, among whom 81 (41.5%) had an insertion only reaching the right hemicolon and 114 (58.5%) only reaching the left hemicolon. Therefore, the colonoscopists had to discontinue the colonoscope insertion into the ileocecum. This cross-sectional study investigated the influencing factors for the colonoscopists discontinuing the colonoscopic examination, and discussed when and why the colonoscopists should discontinue the colonoscopic examination.

Complete colonoscope insertion into the ileocecum was judged by the colonoscopist, who could successfully observe the ileocecal valve, appendiceal orifice, or terminal ileum. If any doubt existed, the colonoscopist considered the insertion an incomplete insertion into the ileocecum[8]. The time required for the colonoscope to reach the proximal end of the colon was defined as the insertion time[8].

The data collected in a retrospective manner and taken from the computer graphic database included the following preoperative indexes: the patient's age; sex; type of anesthesia for colonoscopy; type of colonoscope (variable-stiffness or not) and the following intraoperative indexes: fixation; tortuosity; laxity; and redundancy occurring during colonoscopic examination. Fixation was defined as resistance during the insertion or the pull back of the colonoscope body without loop formation, which meant the body was 40 cm into the colon cavity, after the colonoscope head passed through the descending sigmoid flexure, or 60 cm near the hepatic flexure by the removal of

Table 1 Kudo's colonoscopist level classification

Colonoscopist level	Presentation of correlative level
Ⅰ	Mostly beginners, able to push forward the colonoscope body in the colon cavity; unable to use the method of the colon axis constriction to shorten the length of the colon
Ⅱ	Able to push the colonoscope through the descending sigmoid flexure by α-loop or N-loop, and pull back the colonoscope to set free the loop when the colonoscope head reaches the transverse colon; then, use the method mentioned above
Ⅲ	Able to control the colonoscope passing through the descending sigmoid flexure by α-loop or N-loop, and pull back the colonoscope to set free the loop when it reaches the descending colon; then, use the above-mentioned method
Ⅳ	Able to control the colonoscope and keep the colon axis constriction from rectosigmoid flexure, pushing the colonoscope passing through the descending sigmoid flexure without loop formation

the colon loop. Fixation was caused by abdominal surgical adhesions[9], peritonitis, abdominopelvic cancer, abdominopelvic radiotherapy, or intestinal adhesions of unknown origin. Tortuosity was defined as sharp turns[9] or convolutions of the colon during the insertion of the colonoscope body without loop formation, which often occurred in the physiological flexures, *e.g.*, the descending sigmoid flexure and the rectosigmoid flexure. Laxity was defined as no or low resistance during the insertion of the colonoscope; even if the loop formation was felt by the colonoscopists, the colonoscope body was still easy to insert, but the head could not go deep into the colon cavity. Redundancy was defined as tedium of the colon during the insertion of the colonoscope without resistance or loop formation, but the colon could not be shortened because of the loss of the hooked points by the physiological flexure.

General anesthesia: sulfentanyl 0.1 μg/kg was given *via* a slow intravenous injection (iv); then, midazolam 1 mg iv after the nasal oxygen inhalation. If the patient had stable vital signs with no bucking or body movements, propofol 1.5-2.5 mg/kg *iv* could be given at a rate of 2 mL/10-20 s. The patient's spontaneous respiration should be kept, and all the body muscles should be relaxed without lash reflex[10]. If the patient was restless, propofol 0.5-1 mg/kg was given, maintaining the patient in a painless state until the end of the examination.

Types of colonoscopes: variable-stiffness colonoscopes[11,12] including CF 240AH and CF 240AI (Olympus Optical Co. Ltd., Tokyo, Japan); invariable-stiffness colonoscopes including CF 240, CF 240I (Olympus Optical Co. Ltd., Tokyo, Japan), and Fujinon EC-410D (Fujinon Optical Co. Ltd., Tokyo, Japan).

Statistical analysis was performed using SPSS (version 13.0). *t*-test, Univariate and multivariate logistic regression analyses were performed, and a P value < 0.05 was considered statistically significant.

Table 2 Kudo's classification of colonoscopy difficulty

Difficulty classification	Presentation of correlative pattern
Grade A	Relatively short sigmoid colon, easy to be shortened. Applied to most young and middle-aged men. 2-3 min taken to reach the cecum
Grade B	Lengthy sigmoid colon and relatively tortuous descending sigmoid flexure, easier to form a loop
Grade C	Sigmoid colon with local or partial adhesion after abdominal disease, surgery, or unusually long sigmoid colon, with or without obvious tortuous descending sigmoid flexure, easier to form a loop

RESULTS

General conditions of patients

Of the 517 patients undergoing colonoscopic examination, 322 (≥ 60 years in 153; < 60 years in 169; 136 male, 186 female; 201 given anesthesia, 121 given no anesthesia; 171 using variable-stiffness colonoscope, 151 using invariable-stiffness colonoscope) had a complete insertion into the ileocecum, and the other 195 had an incomplete insertion into the ileocecum, among whom 81 (≥ 60 in 41, < 60 in 40; 57 male, 24 female; 53 given anesthesia, 28 given no anesthesia; 46 using variable-stiffness colonoscope, 35 using invariable-stiffness colonoscope) had the colonoscope reaching the right hemicolon, and the other 114 (≥ 60 in 42, < 60 in 72; 60 male, 54 female; 73 given anesthesia, 38 given no anesthesia; 53 using variable-stiffness colonoscope, 61 using invariable-stiffness colonoscope) had the colonoscope reaching the left hemicolon.

Incompletion rates and reasons for colonoscopy being discontinued by colonoscopists

Of the 195 incomplete colonoscope insertions, 81 (41.5%) were discontinued by the colonoscopists when the endoscope reached the right hemicolon (ascending colon, hepatic flexure, transverse colon) and the other 114 (58.5%) were discontinued when the endoscope reached the left hemicolon (between rectosigmoid flexure and splenic flexure). The most common sites where the endoscope insertions were discontinued were the hepatic flexure in the right hemicolon (45 cases, 23.1%) and the descending sigmoid flexure (40 cases, 20.5%) in the left hemicolon. The reasons for discontinuation by the colonoscopists were fixation, tortuosity, laxity, and redundancy occurring in the left hemicolon and the right hemicolon (Table 3).

Comparisons of influencing factors between difficult colonoscope insertion into the left hemicolon and difficult but complete colonoscope insertion into ileocecum

Among the 322 difficult insertions into the ileocecum, 223 (69.3%) encountered fixation, 144 (44.7%) encountered tortuosity, 93 (28.9%) encountered laxity, and 25 (7.8%) encountered redundancy.

Table 3 Sites for colonoscopy discontinuation and reasons for discontinuation *n* (%)

Site	Value	Fixation	Tortuosity	Laxity	Redundance
Right hemicolon					
Ascending colon	10 (5.1)	9	4	3	3
Hepatic flexure	45 (23.1)	41	30	5	12
Transverse colon	26 (13.3)	22	15	2	7
Left hemicolon					
Splenic flexure	9 (4.6)	8	8	2	0
Descending colon	14 (7.2)	13	11	4	1
Descending sigmoid flexure	40 (20.5)	35	39	6	2
Sigmoid colon	29 (14.9)	27	26	2	1
Rectosigmoid flexure	22 (11.3)	22	19	0	0
Total	195 (100)	177	152	24	26

Table 4 Factors related to sites for colonoscope reaching left hemicolon and right hemicolon

	Left hemicolon			Right hemicolon		
	OR	95%CI	*P* value	OR	95%CI	*P* value
Preoperative variable						
Sex (female *vs* male)	0.69	0.41-1.17	0.17	0.35	0.20-0.63	< 0.001
Age (> *vs* ≤ 60 yr)	1.63	0.95-2.80	0.08	0.88	0.50-1.52	0.64
Anesthesia (yes *vs* no)	0.74	0.43-1.30	0.30	0.98	0.55-1.75	0.93
Type of colonoscope (yes *vs* no)	0.88	0.50-1.53	0.64	1.11	0.62-2.00	0.72
Intraoperative variable						
Fixation (yes *vs* no)	0.06	0.03-0.16	< 0.001	0.16	0.06-0.39	< 0.001
Tortuosity (yes *vs* no)	0.04	0.02-0.08	< 0.001	0.23	0.13-0.43	< 0.001
Laxity (yes *vs* no)	0.56	0.24-1.33	0.19	1.16	0.50-2.71	0.73
Redundancy (yes *vs* no)	0.80	0.21-3.10	0.75	0.12	0.05-0.26	< 0.001

Among the 114 difficult insertions that only reached the left hemicolon, 105 (92.1%) encountered fixation, 103 (90.4%) encountered tortuosity, 14 (12.3%) encountered laxity, and 4 (3.5%) encountered redundancy.

Univariate analysis revealed that there were significant differences in fixation and tortuosity between the above two conditions ($P < 0.001$). They could be used as an indicator for colonoscopy, and they were the inverse factors significantly related to the colonoscope insertion into the ileocecum. However, difficulties of insertion into the ileocecum were not associated with the patient's age, sex, anesthesia use, colonoscope type or the colon influencing factors, *e.g.*, laxity and redundancy.

Multivariate logistic regression analysis also revealed that fixation (OR = 0.06, 95%CI: 0.03-0.16, $P < 0.001$) and tortuosity (OR = 0.04, 95%CI: 0.02-0.08, $P < 0.001$) were independent inverse factors significantly related to the insertion into the ileocecum, but the other indexes, *e.g.*, age, sex, laxity, and redundancy, were not that kind of factor ($P > 0.05$) (Table 4).

Comparisons of influencing factors between difficult colonoscope insertion into the right hemicolon and difficult but complete colonoscope insertion into the ileocecum

Among the 81 difficult insertions reaching the right hemicolon, 72 (88.9%) encountered fixation, 49 (60.5%) encountered tortuosity, 10 (12.3%) encountered laxity, and 22 (27.2%) encountered redundancy.

Univariate analysis revealed that there were significant differences in fixation, tortuosity and redundancy between the above two conditions ($P < 0.001$). They could be used as an indicator for colonoscopy, and they were the inverse factors significantly related to the colonoscope insertion into the ileocecum. The insertions only reaching the right hemicolon in the male patients were significantly greater in frequency than those in the female patients ($P < 0.001$). However, difficulties of insertion into the ileocecum were not associated with the patient's age, anesthesia use, colonoscope type or colon influencing factors, *e.g.*, laxity.

Multivariate logistic regression analysis also revealed that fixation (OR = 0.16, 95%CI: 0.06-0.39, $P < 0.001$), tortuosity (OR = 0.23: 95%CI: 0.13-0.43, $P < 0.001$) , redundancy (OR = 0.12, 95%CI: 0.05-0.26, $P < 0.001$), and sex (OR = 0.35, 95%CI: 0.20-0.63, $P < 0.001$) were independent inverse factors significantly related to insertion into the ileocecum, but the other indexes, *e.g.*, age, laxity, and redundancy were not that kind of factor ($P > 0.05$) (Table 4). There were no colonoscopy-related complications during or within 7 d of the procedure.

Factors influencing insertion time in left hemicolon

In the 322 difficult colonoscope insertions into the

Table 5 Factors related to insertion time (> 10 min) in left hemicolon and right hemicolon

	Left hemicolon			Right hemicolon		
	OR	95%CI	*P* value	OR	95%CI	*P* value
Preoperative variable						
Sex (female *vs* male)	1.30	0.86-1.96	0.22	1.47	0.96-2.26	0.08
Age (> 60 yr *vs* ≤ 60 yr)	1.18	0.78-1.79	0.43	1.35	0.88-2.06	0.17
Anesthesia (yes *vs* no)	0.68	0.44-1.03	0.07	0.84	0.54-1.30	0.43
Type of colonoscope (yes *vs* no)	0.68	0.45-1.04	0.08	0.61	0.39-0.94	0.02
Intraoperative variable						
Fixation (yes *vs* no)	0.99	0.55-1.79	0.98	1.92	1.04-3.52	0.04
Tortuosity (yes *vs* no)	1.80	1.14-2.86	0.01	2.40	1.51-3.82	< 0.001
Laxity (yes *vs* no)	1.62	0.92-2.85	0.10	1.53	0.87-2.70	0.14
Redundancy (yes *vs* no)	2.44	1.09-5.44	0.03	4.65	2.30-9.39	< 0.001

ileocecum, the insertion mean time was 9.6 ± 4.4 min (range: 2.9-44.4 min); in the 114 difficult colonoscope insertions only reaching the left hemicolon, the insertion mean time was 9.4 ± 7.2 min (range: 1.4-42.5 min). No significant difference was found in the insertion mean time between the above two conditions ($P > 0.2$), but based on the univariate analysis, a significant difference was still found in tortuosity ($P < 0.05$) and redundancy ($P < 0.05$) between the above two conditions. They could be used as an indicator for colonoscopy, and they were significant factors related to the insertion time (> 10 min) in the patients whose colonoscopy only reached the left hemicolon. However, the time for the colonoscope insertion into the ileocecum was not related to the patient's age, anesthesia use, colonoscope type or the colon influencing factors, *e.g.*, fixation and laxity.

Multivariate logistic regression analysis also revealed that tortuosity (OR = 1.80, 95%CI: 1.14-2.86, $P = 0.01$) and redundancy (OR = 2.44, 95%CI: 1.09-5.44, $P = 0.03$) were significant factors related to the insertion time (>10 min) but the other indexes, *e.g.*, age, sex, fixation, and laxity were not that kind of factors ($P > 0.05$) (Table 5).

Factors influencing the insertion time in the right hemicolon

In the 81 difficult colonoscope insertions only reaching the right hemicolon, the insertion mean time was 17.6 ± 7.8 min (range: 5.1-48.7 min) but the insertion mean time for the colonoscope insertions into the ileocecum was 9.6 ± 4.4 min (range: 2.9-44.4 min). There was a significant difference in the insertion mean time between the above two conditions ($P < 0.01$).

Univariate analysis revealed that fixation ($P < 0.05$), tortuosity ($P < 0.01$) and redundancy ($P < 0.01$), which could be used as an indicator for colonoscopy, were significant factors related to the insertion time (> 10 min) in patients whose colonoscope insertion only reached the right hemicolon, but the type of colonoscopes were inverse factors significantly related to the insertion time (> 10 min) in patients whose colonoscope insertion only reached the right hemicolon ($P < 0.05$). However, the time for the insertion into the ileocecum was not associated with the patient's age, sex, anesthesia use or the colon influencing factor, *e.g.*, laxity.

Multivariate logistic regression analysis also revealed that fixation (OR = 1.92: 95%CI: 1.04-3.52, $P = 0.04$), tortuosity (OR = 2.40, 95%CI: 1.51-3.82], $P < 0.001$), and redundancy (OR = 4.65, 95%CI: 2.30-9.39, $P < 0.001$) were significant factors related to the insertion time (> 10 min), but the types of colonoscopes were independent inverse factors significantly related to the insertion time (> 10 min). However, the other indexes, *e.g.*, age, sex, anesthesia use, and laxity were not related to insertion time ($P > 0.05$) (Table 5).

The reasons for discontinuation of colonoscopy insertions by the colonoscopists were fixation (72, 36.9%; 105, 53.8%), tortuosity (49, 25.1%; 103, 52.8%), laxity (10, 5.0%; 14, 7.2%), and redundancy (22, 11.3%; 4, 2.1%) in the right hemicolon and the left hemicolon, respectively.

DISCUSSION

In the field of digestive endoscopy, colonoscopy is a challenging procedure only secondary to small intestine endoscopy in the toughness degree. So, a safe and efficient colonoscope insertion into the ileocecum is a fundamental task for all the colonoscopists[8]. The success in colonoscopy chiefly depends on the following three factors: patients, colonoscopists, and types of colonoscopes. Among these three factors, the colonoscopists are the most important factor, whose operative skills play a decisive role in successful colonoscopy. The colonoscopists are usually confronted by the following four difficulties: fixation, tortuosity, laxity, and redundancy occurring in the colon, which lead to the loss of freedom of the colonoscope body's insertion and rotation. If the colonoscopists could not overcome one or more difficulties, successful colonoscope insertion into the ileocecum would be an arduous task. According to Kudo's classification criterion[3], the 4th-

level (top level) colonoscopist can smoothly insert the colonoscope into the ileocecum within 3-5 min though faced by the Grade C (the most difficult grade) patient without any obvious looping formation, achieving a 95%-98% success rate of insertion into the ileocecum.

To solve the problem of the remaining (2%-5%) incomplete colonoscope insertions into the ileocecum, so many pre-examination evaluation indexes were put forward in the medical literature[5,13-15], *e.g.*, the patient's body posture, age, sex, body mass index, constipation, and previous abdominal surgery.

The results of the study revealed that the influencing factors for the colonoscope insertion only reaching the left hemicolon were fixation and tortuosity occurring in the colon, and the influencing factors for the insertion only reaching the right hemicolon were fixation, tortuosity, and redundancy. The results also revealed that male patients were more likely to have their insertion only reaching the right hemicolon than female patients. This finding could be explained by the male patients being more likely to have redundancy in the colon. The other factors were not so closely correlated with difficult insertion into the ileocecum.

No statistically significant difference was found in the insertion mean time between the insertions only reaching the left hemicolon and the insertions completely into the ileocecum ($P > 0.2$); however, a significant difference was found in the insertion mean time between the insertions only reaching the right hemicolon and the insertions completely into the ileocecum ($P < 0.01$).

Compared with the difficult insertions into the ileocecum, the insertions only reaching the left hemicolon encountered the same difficult factors (fixation, tortuosity), so there is no difference in the overall time expenditure for a 4th-level expert colonoscopist.

As for the insertion reaching the right hemicolon, the main difficulty was usually due to redundancy in the right hemicolon. The colonoscopists would not easily discontinue the insertion but attempted to use posture change, abdominal compression, hooking the fold for removal of the colon loops to shorten the colon and inserting the colonoscope into the ileocecum. When they still failed and finally discontinued the insertion, much more time was used. This kind of discontinuation was relatively great in proportion in clinical practice.

In the colonoscope insertions reaching the left hemicolon and the right hemicolon, the factors unfavorably influencing the insertion mean time (> 10 min) were different in the following two conditions: tortuosity and redundancy often occurred in the left hemicolon, but fixation, tortuosity, and redundancy often occurred in the right hemicolon. The variable-stiffness colonoscope was a favorable factor for reducing the mean insertion time, but only favorable factor for the colonoscope insertion reaching the right hemicolon.

Evaluation on discontinuation of the colonoscope insertion during colonoscopic examination was made in this study. According to the Kudo's Classification criterion[3], discontinuation of the most difficult insertions usually occurred in the Grade C patients. The result analysis revealed that fixation and tortuosity were the coexistent difficulty factors for influencing the insertion into the ileocecum in both the left hemicolon and the right hemicolon. Thus, during the colonoscopic examination, the following three indexes for judging whether the colonoscope insertion should be discontinued should be considered.

First, the colonoscope insertion time was the most important index for the most difficult colonoscopy. Once the insertion time was prolonged > 10 min in the colonoscopy performed by the 4th-level colonoscopist, this colonoscopy should be considered the most difficult one. At this time, the colonoscopist should determine which influencing factor (fixation, tortuosity, laxity or redundancy) had caused the prolongation of the insertion time, and should determine what position the colonoscope head reached, and what countermeasures should be taken in the next management procedures.

Second, if the colon axis constriction[3] could not be achieved or maintained because of the following one or more influencing factors: fixation, tortuosity, laxity, and redundancy, the colonoscopist should use such assisting techniques as posture change, abdominal compression, and hooking the fold for removal of the colon loops after insertion with the loop, to decrease the degrees of the descending sigmoid flexure and/or hepatic flexure to shorten the length of the colon cavity. If those attempts were still a failure, these kind of patients were considered relatively difficult for colonoscopic examination, and colonoscopic examination should be discontinued.

Third, though the colon axis constriction could be achieved after the above-mentioned efforts[3], *i.e.*, the colonoscope body was 40 cm in the colon cavity after the colonoscope passed through the descending sigmoid flexure, or 60 cm near the hepatic flexure, the freedom of the colonoscope body could still not be obtained[3], and paradoxical movements (the head of the colonoscope back off) happened when the colonoscope was further inserted into the colon cavity. Even if the assisting techniques (posture change, abdominal compression, the hooking of the fold for shortening the colon) were attempted, the colonoscope insertion was still a failure. These kinds of patients were considered relatively difficult for colonoscopic examination, and the examination should be discontinued.

Further measures for difficult insertion that may be discontinued

In management of those difficult colonoscope insertions, 4th-level colonoscopists would often choose

to challenge the limits of the colonoscopic operation technology rather than discontinue colonoscopic examination at once. They would attempt to break through the key difficult points, such as the redundant and fixed right hemicolon, and the tortuous and fixed descending sigmoid flexure. Some of the 4th-level colonoscopists who had a different management style would be asked to continue the operation[16] with professional nurses who were good at the assisting techniques of abdominal compression for the patient[17,18]. They succeeded in their attempts to insert the colonoscope into the ileocecum. But how to explain and copy those individualized technical characteristics of those colonoscopists and nurses is still quite difficult.

In addition, some other assisting techniques have been used as further measures, *e.g.*, changing the type of colonoscope[16], using spiral overtube[19] or cap-assisted colonoscopy[20], water infusion colonoscopy[21,22], and magnetic endoscopic imaging[23,24], which can be attempted even though no sufficient evidence has been found to verify those techniques used to increase the success rate of colonoscope insertion into the ileocecum in those difficult patients.

In short, the reasons for discontinuation of colonoscope insertion into the ileocecum are as follows: in those difficult patients, if the above-mentioned management techniques fail in breaking through those difficult key points after repeated attempts by the expert colonoscopists, the freedom of the colonoscope body in insertion and rotation is completely lost, the colon axis constriction cannot be achieved or maintained after repeated attempts, and the colonoscope insertion should be discontinued.

Considering the mean time of discontinuation in the left hemicolon (about 10 min) and right hemicolon (about 20 min), the time for the discontinuation of the colonoscope insertion into the ileocecum is suggested as follows: the total insertion time is prolonged > 30 min after the repeated attempts by the 4th-level colonoscopists then the colonoscope insertion should be discontinued.

The patients whose colonoscopy insertions are discontinued can still use some other instruments and techniques, *e.g.*, virtual colonoscopy[25,26], single[27] or double-balloon[28] enteroscopy, or colon capsule endoscopy[29,30] if their clinical and economic conditions permit.

COMMENTS

Background

Colonoscopy is not a difficult procedure for most of the colonoscopists now. However, there are still some difficulties in the insertion of the colonoscope; even highly-skilled colonoscopists are unable to guarantee a 100% success rate when the ileocecal intubation is performed. Therefore, to determine when and recognize why this kind of colonoscopic intubation should be discontinued is very important for the colonoscopists.

Research frontiers

Many research indexes, such as age, sex and abdominal surgery have been introduced to predict the success rate of ileocecal intubation. In this paper, four indexes, *i.e.*, fixation, tortuosity, laxity and redundancy were introduced to solve this problem.

Innovations and breakthroughs

The new research indexes, *i.e.*, fixation, tortuosity, laxity and redundancy could only be obtained by the colonoscopists during the examination. These indexes are precise and direct in clarifying the difficulty of colonoscopy and helping the colonoscopists to decide whether they should continue or discontinue the examination at the proper time.

Applications

If freedom of the colonoscope body during the insertion and rotation is completely lost because of fixation, tortuosity, laxity and/or redundancy during the examination, and the insertion time is prolonged > 30 min, the colonoscopy should be discontinued.

Terminology

Colonoscopy is an important commonly-used examination for colonic diseases, such as carcinoma of the colon, polyps of the colon, ulcerative colitis and Crohn's disease. To prevent diagnosis of colonic diseases from failing, the principal task for the colonoscopists to finish is that they should try their best to insert the colonoscope into the ileocecum. Freedom of the colonoscope body during the insertion and rotation will decide its success in the insertion into the ileocecum.

Peer-review

This is an interesting and generally well written paper. Please recommend language polishing to benefit the wider readership.

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