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Feasibility and safety of colonoscopy performed by nonexperts for acute lower gastrointestinal bleeding: post hoc analysis

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ABSTRACT

Background and study aims It remains unclear whether the experience of endoscopists affects clinical outcomes for acute lower gastrointestinal bleeding (ALGIB). We aimed to determine the feasibility and safety of colonoscopies performed by nonexperts using secondary data from a randomized controlled trial for ALGIB.

Patients and methods We analyzed clinical outcomes in 159 patients with ALGIB who underwent colonoscopies performed by two groups of endoscopists: experts and nonexperts. We compared endoscopy outcomes, including identification of stigmata of recent hemorrhage (SRH), successful endoscopic treatment, adverse events (AEs), and clinical outcomes between the two groups, including 30-day rebleeding, transfusion, length of stay, thrombotic events, and 30-day mortality.

Results Expert endoscopists alone performed colonoscopies in 96 patients, and nonexperts performed colonoscopies in 63 patients. The use of antiplatelets and warfarin was significantly higher in the expert group. The SRH identification rate (24.0 and 17.5%), successful endoscopic treatment rate (95.0 and 100%), rate of AEs during colonoscopy (0 and 0%), transfusion rate (6.3 and 4.8%), length

of stay (8.0 and 6.4 days), rate of thrombotic events (0 and 1.8 %), and mortality (0 and 0 %) were not different between the expert and nonexpert groups. Rebleeding within 30 days occurred more often in the expert group than in the nonexpert group (14.3 vs. 5.4 % $P = 0.0914$).

Conclusions The performance of colonoscopies for ALGIB by nonexperts did not result in worse clinical outcomes, suggesting that its use could be feasible for nonexperts for diagnosis and treatment of ALGIB.

Introduction

Colonoscopy is essential for diagnosis and treatment of acute lower gastrointestinal bleeding (ALGIB). However, colonoscopy for ALGIB is an advanced and high-risk endoscopic procedure, and more training and experience are needed to maintain the quality and safety of colonoscopy for ALGIB than conventional colonoscopy. A previous retrospective study with 403 ALGIB patients showed that performance of the colonoscopy by an expert endoscopist was a significantly positive factor for the identification of stigmata of recent hemorrhage (SRH) diverticula, which is an important endoscopic outcome [1]. However, no available high-quality data on the effectiveness and safety of the performance of colonoscopies for ALGIB by nonexpert endoscopists in emergency settings have been reported. In addition, it is necessary to evaluate the associations between the number of years of experience and endoscopic and clinical outcomes in ALGIB patients. The latest colonoscopy core curriculum prepared by the American Society for Gastrointestinal Endoscopy Training Committee stated that a full discussion of the evaluation and treatment of lower gastrointestinal bleeding was beyond the scope of the document [2].

Recently, we performed a randomized controlled trial to evaluate the efficacy and safety of colonoscopy for ALGIB patients [3]. The trial had the largest sample size yet and was the first multicenter study involving nearly 100 endoscopists. In the present study, we performed a post hoc analysis of the trial data. This study was performed to investigate the feasibility of colonoscopy by nonexpert endoscopists in ALGIB patients.

Patients and methods

Study subjects

This study is a post hoc analysis from a multicenter randomized controlled trial (RCT) of early and elective colonoscopy for ALGIB that investigated the efficacy and safety of the former for patients with ALGIB [3, 4]. Briefly, this RCT was an open-label study, and 170 patients aged ≥ 20 years presenting with moderate-to-severe hematochezia or melena within 24 hours of arrival were randomly assigned (1:1) to either receive an early colonoscopy (within 24 hours of the initial visit to the hospital) or an elective colonoscopy (24–96 hours after hospital admission). The study was conducted at 15 hospitals in Japan from July 2016 until May 2018. Of the 170 enrolled patients, a total of 162 underwent randomization; three were excluded, and 159 were included in the modified intention-to-treat population. This post hoc analysis was approved by the institutional review boards of all participating hospitals.

Colonoscopy and endoscopists

All endoscopists were divided into two categories: experts and nonexperts. An expert endoscopist was defined as having conducted more than 1000 colonoscopies and as having performed endoscopic hemostasis, with board certification from the Japanese Gastroenterological Endoscopy Society (JGES); other endoscopists were considered nonexperts. We evaluated the years of experience with endoscopy. The selection of nonexpert endoscopists in an emergency setting depended on each institution's policy and patient background. This study protocol allowed a nonexpert endoscopist to perform a colonoscopy under the supervision of an expert endoscopist who provided verbal advice. When a nonexpert endoscopist met with difficulties or took longer to perform the procedure and when safety concerns for the patient arose, an expert endoscopist took over.

Colonoscopies were performed as video endoscopies (Fujifilm Corporation, Tokyo, Japan, or Olympus Optical, Tokyo) after oral bowel preparation with 2 to 4 L polyethylene glycol-electrolyte solution; an additional enema was allowed to be administered to patients in the case of inadequate bowel cleansing. The quality of bowel preparation was evaluated using the Aronchick scale [5]. The preparation quality was defined as adequate when excellent and good results were obtained.

An attachment cap and a water-jet device were used for all colonoscopy procedures. Attending physicians decided when to discontinue and resume medications such as nonsteroidal anti-inflammatory drugs, antiplatelet drugs, or anticoagulants.

Endoscopic outcomes and clinical outcomes

The endoscopic outcomes were the cecum insertion rate and time, completion rate of insertion by nonexperts alone, total procedure time, rate of identification of SRH, success rate of endoscopic treatment, completion rate of successful endoscopic treatment by nonexperts alone, need for additional endoscopic examinations, and colonoscopy-related adverse events (AEs). Clinical outcomes were the need for interventional radiology, need for surgery, need for transfusion during hospitalization, length of hospital stay, 30-day rebleeding rate, and 30-day mortality rate. Thirty-day rebleeding was defined as significant fresh blood in the stool after the initial colonoscopy with any of the following: 1) hemorrhagic shock; 2) need for transfusion; 3) identification of blood pooling on further colonoscopy; v) SRH in the lower gastrointestinal tract; or 5) extravasation identified in the colorectal region on contrast-enhanced computed tomography.

Statistical analysis

Continuous variables were compared using Wilcoxon's rank-sum test. Categorical variables were compared using the χ^2 test or Fisher's exact test. *P* value indicating statistical significance of the primary outcome was set at < 0.05 for two-tailed tests.

As a sensitivity analysis, we performed a 1:1 propensity score-weighted analysis to balance covariates between the expert and nonexpert groups. A logistic regression model was used to calculate propensity scores for each patient in the group, including as covariates all of the following clinical characteristics: age, sex, body mass index, height, weight, level of hemoglobin, systolic and diastolic blood pressures, heart rate at admission, use of medications (NSAIDs, low-dose aspirin, thienopyridine, cilostazol, other antiplatelet drugs, warfarin, direct oral anticoagulants), and the presence of comorbidities (previous lower gastrointestinal bleeding, ischemic heart disease, chronic obstructive pulmonary disease, peptic ulcer, liver cirrhosis, diabetes mellitus, chronic heart failure, cerebrovascular disease, dementia, collagen disease, chronic kidney disease, leukemia, malignant lymphoma, solid tumors), and allocation to the early colonoscopy group.

As a subgroup analysis, we categorized the nonexpert group into two groups: < 3 years of endoscopic experience and 3 to 6 years of endoscopic experience, according to the distribution of the obtained data (data not shown). We compared endoscopic and clinical outcomes between the group with < 3 years of endoscopic experience and the expert group and between the group with 3 to 6 years of endoscopic experience and the expert group.

The statistical analyses were performed with SAS software v. 9.4 (SAS Institute, Cary, North Carolina, United States).

Results

Baseline patient characteristics

▶ Table 1 shows patient characteristics. The expert group performed colonoscopies in 96 patients, and the nonexpert group performed colonoscopies in 63 patients at the 12 participating hospitals. The expert group had a mean of 10.52 years of endoscopy experience and the nonexpert group had a mean of 4.32 years of experience.

The proportions of patients with ischemic heart disease (26 %), who used low-dose aspirin (31.3 %) and who used warfarin (9.4 %) in the expert group were significantly higher than those in the nonexpert group (7.9 %, 12.7 %, 1.6 %). However, the other comorbidities, medications, presence of hemodynamic instability, and hemoglobin levels were similar between the groups (▶ Table 1). Bleeding sources were similar in the two groups (▶ Table 2).

Endoscopic outcomes and clinical outcomes

▶ Table 2 shows endoscopic and clinical outcomes. Rates of adequate bowel preparation were 96.9 % in the expert group and 100 % in the nonexpert group, which were similar and sufficient. The cecum insertion rate was 95.8 % in the expert group

and 98.4 % in the nonexpert group. The cecum insertion time of the expert group was significantly shorter than that of the nonexpert group (8.1 ± 5.8 and 11.0 ± 7.2 minutes, *P* = 0.0061), but no significant difference in total procedure time was observed between the groups. The completion rate of insertion by nonexperts alone was 98.41 % (62/63).

The identification rate for SRH did not differ between the two groups, and endoscopic findings of bleeding sources were similar between the groups. The success rate for endoscopic treatment and the need for additional endoscopic examinations were also no different between the groups. The completion rate for successful endoscopic treatment by nonexperts alone was 100 % (63/63). Preparation-related AEs were similar between the groups and were not severe. With regard to colonoscopy-related AEs, hemorrhagic shock occurred in one patient (1.0 %) in the expert group and 0 patients in the nonexpert group. No perforation occurred in either group. Rebleeding within 30 days occurred in 14.3 % of patients in the expert group and 5.4 % of patients in the nonexpert group (*P* = 0.091). No difference was observed in the need for interventional radiology, surgery, or transfusion between the groups. The mean length of hospital stay was 8.0 days in the expert group and 6.4 days in the nonexpert group (▶ Table 2).

Propensity score-weighted analysis

Details of the baseline characteristics in each group after weighting are shown in ▶ Table 3. After weighting, there were no significant differences in cecum insertion rate, total procedure time, or bleeding sources between the two groups. There were no significant differences in SRH identification, successful endoscopic treatment rate, transfusion rate, length of stay, thrombotic events, 30-day rebleeding rate, or 30-day mortality rate between the two groups. AEs did not differ between the groups (▶ Table 4). These findings remained unchanged in the propensity score-weighted analysis.

Subgroup analysis according to years of endoscopic experience

Similarly, we compared endoscopic and clinical outcomes between the group with < 3 years of endoscopic experience (N = 8, ▶ Table 5) and the expert group and between the group with 3 to 6 years of endoscopic experience (N = 32, ▶ Table 6) and the expert group. The SRH identification rate was higher in the expert group than in both nonexpert groups; however, the differences were not significant. Endoscopic findings of the bleeding sources were similar between the expert group and both nonexpert groups. Colonoscopy-related AEs also were similar. Rebleeding within 30 days occurred more often in patients in the expert group than in either nonexpert group, and the length of stay was significantly longer in the expert group than in the nonexpert group with < 3 years of experience (▶ Table 5, ▶ Table 6).

▶ **Table 1** Baseline patient characteristics.

Characteristics	Expert (N = 96)	Nonexpert (N = 63)	P value
Age (years), mean ± SD	70.9 ± 12.9	69.6 ± 12.1	0.5383
Sex, male (%)	62 (64.6)	44 (69.8)	0.4915
Body mass index, mean ± SD	23.5 ± 4.1	23.3 ± 3.0	0.7757
Comorbidities			
▪ Previous lower gastrointestinal bleeding (%)	39 (40.6)	19 (30.2)	0.1799
▪ Charlson comorbidity index	1.5 ± 1.7	1.2 ± 1.9	0.2943
▪ Ischemic heart diseases	25 (26.0)	5 (7.9)	0.0043
▪ Chronic obstructive pulmonary disease	2 (2.1)	1 (1.6)	0.8221
▪ Peptic ulcer	5 (5.2)	3 (4.8)	0.8998
▪ Liver cirrhosis	1 (1.0)	2 (3.2)	0.3336
▪ Diabetes mellitus	18 (18.8)	9 (14.3)	0.4634
▪ Chronic heart failure	8 (8.3)	1 (1.6)	0.0718
▪ Cerebral vascular diseases	20 (20.8)	6 (9.5)	0.0593
▪ Dementia	0 (0.0)	2 (3.2)	0.0789
▪ Collagen diseases	7 (7.3)	2 (3.2)	0.2718
▪ Chronic kidney disease	13 (13.5)	6 (9.5)	0.4449
▪ Leukemia	1 (1.0)	0 (0.0)	0.4164
▪ Malignant lymphoma	2 (2.1)	0 (0.0)	0.2489
▪ Solid cancer	10 (10.4)	9 (14.3)	0.4619
▪ Metastatic cancer	1 (1.0)	2 (3.2)	0.3336
▪ Acquired immunodeficiency syndrome	0 (0.0)	0 (0.0)	Not applicable
Medication			
▪ Low dose aspirin	30 (31.3)	8 (12.7)	0.0073
▪ Thienopyridine	11 (11.5)	2 (3.2)	0.0622
▪ Cilostazol	4 (4.2)	3 (4.8)	0.858
▪ Other antiplatelet drugs	2 (2.1)	6 (9.5)	0.0358
▪ Warfarin	9 (9.4)	1 (1.6)	0.0479
▪ Direct oral anticoagulants	8 (8.3)	2 (3.2)	0.19
▪ NSAIDs	20 (20.8)	10 (15.9)	0.4343
Initial assessment			
▪ Hemodynamic instability	3 (3.1)	2 (3.2)	0.986
▪ Hemoglobin (g/dL)	11.4 ± 2.4	11.2 ± 2.6	0.6914
▪ Upper endoscopy before colonoscopy	2 (2.1)	1 (1.6)	0.8221
▪ Early colonoscopy group	48 (50.0)	31 (49.2)	0.922

GI, gastrointestinal; NSAIDs, nonsteroidal anti-inflammatory drugs.

▶**Table 2** Endoscopic outcomes, adverse events, and clinical outcomes.

Outcomes	Expert, (%) N = 96	Nonexert, (%) N = 63	P value
Endoscopic outcomes			
▪ Aronchick scale Excellent/good/fair	83 (86.5)/10 (10.4)/3 (3.1)	58 (92.1)/5 (7.9)/0 (0)	0.3086
▪ Cecum insertion	92 (95.8)	62 (98.4)	0.362
▪ Completion rate of insertion without expert assist	Not applicable	62 (98.4)	Not applicable
▪ Time to the cecum (min), mean ± SD	8.1 ± 5.8	11.0 ± 7.2	0.0061
▪ Total procedure time (min), mean ± SD	32.9 ± 18.9	34.5 ± 14.9	0.5761
▪ SRH identification	23 (24.0)	11 (17.5)	0.3284
Bleeding source by Colonoscopy findings			
▪ Diverticular (definite)	16 (16.7)	10 (15.9)	0.8947
▪ Diverticular (presumptive)	41 (42.7)	32 (50.8)	0.317
▪ Rectal ulcer	0 (0.0)	0 (0.0)	Not applicable
▪ Colorectal cancer	4 (4.2)	1 (1.6)	0.362
▪ Ischemic colitis	8 (8.3)	6 (9.5)	0.7956
▪ Infectious colitis	0 (0.0)	1 (1.6)	0.2156
▪ Radiation colitis	1 (1.0)	0 (0.0)	0.4164
▪ Colonic ulcer	0 (0.0)	2 (3.2)	0.0789
▪ Nonspecific colitis	0 (0.0)	0 (0.0)	Not applicable
▪ Hemorrhoid	3 (3.1)	0 (0.0)	0.1566
▪ Others	11 (11.5)	3 (4.8)	0.145
▪ Unknown	16 (16.7)	10 (15.9)	0.8947
▪ Upper gastrointestinal bleeding	1 (1.0)	0 (0.0)	0.4164
Success rate of endoscopic treatment	19/20 (95.0)	10/10 (100)	0.472
Completion rate of successful endoscopic treatment without expert assist	Not applicable	63 (100)	Not applicable
Any adverse event			
▪ Preparation-related adverse events	33 (34.4)	25 (39.7)	0.4965
▪ Nausea/vomiting	2 (2.1)	5 (7.9)	0.1145
▪ Abdominal pain	1 (1.0)	1 (1.6)	1.0000
▪ Volume overload	0	0	Not applicable
▪ Aspiration pneumonia	0	0	Not applicable
▪ Hemorrhagic shock	1 (1.0)	1 (1.6)	1.0000
▪ Exacerbation bleeding	32 (33.3)	21 (33.3)	1.0000
▪ Ileus	0	0	Not applicable
▪ Colonoscopy related adverse events	1 (1.0)	0 (0.0)	1.0000
▪ Hemorrhagic shock	1 (1.0)	0 (0.0)	1.0000
▪ Perforation	0 (0.0)	0 (0.0)	Not applicable
SeriousaAdverse events			
▪ Acute myocardial infarction	0	1 (1.6)	0.3962
▪ Bacterial cellulitis	1 (1.0)	0	1.0000

▶ **Table 2** (Continuation)

Outcomes	Expert, (%) N = 96		Nonexert, (%) N = 63		P value
Clinical outcome	N		N		
▪ Need for additional endoscopic examinations	96	36 (37.5)	63	18 (28.6)	0.2449
▪ Need for interventional radiology	96	1 (1.0)	63	0 (0.0)	0.4164
▪ Need for surgery	96	0 (0.0)	63	0 (0.0)	Not applicable
▪ Need for transfusion during hospitalization	95	6 (6.3)	63	3 (4.8)	0.6799
▪ Length of stay (day)[1]	96	8.0 (6.8)	63	6.4 (3.9)	0.0449
▪ 30-day rebleeding	91	13 (14.3)	56	3 (5.4)	0.0914
▪ 30-day thrombosis events	91	0 (0.0)	56	1 (1.8)	0.2009
▪ 30-day mortality	92	0 (0.0)	56	0 (0)	Not applicable

SRH, stigmata of recent hemorrhage.
[1] Data are summarized as the mean (and SD).

Discussion

Contrary to our hypothesis, we found that the rate of SRH identification, rate of successful endoscopic hemostasis, 30-day rebleeding rate, and AEs did not differ between the expert and nonexpert groups. In addition, we performed a subgroup analysis according to the number of years of endoscopy experience among nonexperts; however, nonexperts performed as well as experts regardless of their years of experience.

A possible explanation is that it is difficult for even experts to achieve a higher rate of SRH identification in cases of diverticular bleeding [6], which accounts for approximately 30 % to 50 % of cases of ALGIB [7–9], as these cases involve intermittent bleeding or spontaneous cessation of bleeding [6, 10]. Another explanation is that the completion rate of insertion by nonexperts alone was as high as 98.4 %, suggesting that the nonexpert group may be quite experienced.

In the present study, the length of hospital stay was significantly longer in the expert group than in the nonexpert group. In addition, the 30-day rebleeding rate in the expert group was not significantly higher than that in the nonexpert group. We believe this is because the expert group had higher proportions of patients with ischemic heart diseases, chronic heart failure, or cerebral vascular diseases. Therefore, there were more patients taking antithrombotic drugs in the expert group than in the nonexpert group, which resulted in a higher rebleeding rate in the former group. Consequently, there was a bias in selection of patients undergoing colonoscopies performed by experts. To adjust for this bias, we conducted a propensity score-weighted analysis. After propensity score weighting, we found that the insertion time of the nonexperts was longer by 3 minutes than that of the experts. However, there were no significant differences in the SRH identification rate and bleeding source as primary outcomes between the two groups. Performance of the colonoscopy by a nonexpert can lead to a significant prolongation of the cecum insertion time by 3 minutes, but the total

procedure time and the rate of successful endoscopic treatment were similar between the two groups. Therefore, this prolongation of insertion time may not affect the primary outcomes, including diagnosis and endoscopic treatment. Furthermore, the performance of endoscopic therapies, such as clipping, bipolar coagulation, and band ligation, was also similar between the two groups (data not shown). Therefore, these factors may have contributed to the lack of differences in the clinical outcomes, including the 30-day rebleeding rate and AE rate, between the groups.

Training operators to perform endoscopic procedures, including diagnostic and therapeutic procedures, is a key objective of endoscopy fellowships. To gain competency, trainees generally learn endoscopic procedures through hands-on experience under the supervision of experts [11]. Regarding training programs to increase the adenoma detection rate (ADR) and to decrease the incidence of overlooking interval colorectal cancer, routine monitoring colonoscopy quality metrics can be useful to improve the effectiveness of screening colonoscopies [12]. However, improving the identification of SRH is still challenging even for experts because SRH is rare, and it is even more difficult after successful endoscopic hemostasis [13]. By contrast, a greater degree of safety in the nonexpert group was shown in our study. Therefore, we believe that the endoscopic procedure performed by nonexperts for ALGIB is acceptable and can be included in the training program.

Our study has several strengths. First, our multicenter RCT is the first to evaluate the feasibility of the performance of colonoscopies by nonexpert endoscopists for patients with ALGIB. Second, we performed further investigations to explore the data in more depth. Nevertheless, there are several limitations of the study. First, patients were not randomly allocated to the expert and nonexpert groups. Second, there were no standardized criteria used to select the nonexpert endoscopists who performed colonoscopies in the participating hospitals. We also should consider the potential for selection bias, as the ex-

▶ Table 3 Patient characteristics after propensity score weighting.

Characteristics	Expert, %	Nonexpert, %	P value	Standarized difference
Age, mean ± SD	67.5 ± 10.0	67.6 ± 10.1	0.966	0.011969
Sex, male (%)	67.6	67.3	0.971	0.04153
Body mass index, mean ± SD	23.4 ± 2.3	23.5 ± 2.2	0.807	0.044433
Comorbidities				
▪ Previous lower GI bleeding (%)	32.0	33.2	0.896	0.20694
▪ Charlson comorbidity index	0.7 ± 0.7	0.7 ± 0.9	0.9	0
▪ Ischemic heart diseases (%)	6.8	7.1	0.943	0.11416
▪ Chronic obstructive pulmonary disease (%)	51	51	0.999	0
▪ Peptic ulcer (%)	3.6	4.4	0.825	0.41008
▪ Liver cirrhosis (%)	0	0	0.812	0
▪ Diabetes mellitus (%)	12.4	12.0	0.954	0.10899
▪ Chronic heart failure (%)	0	0	0.549	Not applicable
▪ Cerebral vascular diseases (%)	12.3	11.9	0.943	0.12952
▪ Dementia (%)	0	0		Not applicable
▪ Collagen diseases (%)	5.0	4.7	0.935	0.1495
▪ Chronic kidney disease (%)	6.3	7.6	0.778	0.49294
▪ Leukemia (%)	0	0		Not applicable
▪ Malignant lymphoma (%)	0	0		Not applicable
▪ Solid cancer (%)	8.1	8.0	0.993	0.01764
▪ Metastatic cancer (%)	0	0		Not applicable
▪ Acquired immunodeficiency syndrome	0	0		Not applicable
Medication				
▪ Low dose aspirin	14.0	14.1	0.983	0.03736
▪ Thienopyridine	5.2	4.7	0.906	0.22894
▪ Cilostazol	3.6	3.0	0.851	0.36283
▪ Other antiplatelet drugs	3.4	3.1	0.94	0.1275
▪ Warfarin	2.5	2.4	0.969	0.06442
▪ Direct oral anticoagulants	4.4	3.8	0.875	0.28242
▪ NSAIDs	17.2	18.5	0.858	0.31727
Initial assessment				
▪ Hemodynamic instability	5.6	4.4	0.783	0.54683
▪ Hemoglobin, g/dL	11.9 ± 1.5	11.8 ± 1.9	0.909	0.058421
▪ Upper endoscopy before colonoscopy	0	0	0.712	0
▪ Early colonoscopy group	41.9	44.7	0.776	0.41894

Parenthesis shows %.
NSAIDs, nonsteroidal anti-inflammatory drugs.

▶ Table 4 Endoscopic outcomes, adverse events, and clinical outcomes after propensity score weighting.

Outcomes	Expert, %	Nonexpert, %	P value
Endoscopic outcomes			
▪ Cecum insertion	95.36	97.64	0.559
▪ Time to the cecum (min), mean ± SD	7.6 ± 3.6	10.6 ± 5.8	0.018
▪ Total time (min), medan ± SD	34.9 ± 12.7	34.7 ± 11.9	0.949
▪ SRH identification	24.05	17.57	0.4163
Bleeding source by Colonoscopy findings			
▪ Diverticular (definite)	15.51	15.22	0.967
▪ Diverticular (presumptive)	43.35	48.34	0.609
▪ Rectal ulcer	0	0	Not applicable
▪ Colorectal cancer	4.43	0.87	0.17
▪ Ischemic colitis	10.99	10.97	0.997
▪ Infectious colitis	0	2.19	Not applicable
▪ Radiation colitis	1.02	0	Not applicable
▪ Colonic ulcer	0	0	Not applicable
▪ Nonspecific colitis	0	0	Not applicable
▪ Hemorrhoid	4.91	0	Not applicable
▪ Others	5.1	4.55	0.891
▪ Unknown	17.84	20.05	0.779
▪ Upper gastrointestinal bleeding	0	0	Not applicable
The success rate of endoscopic treatment	97.14	100	0.3263
Completion rate of successful endoscopic treatment without expert assist	Not applicable	63 (100)	Not applicable
Adverse event			
▪ Preparation-related adverse events	37.4	37.3	0.9885
▪ Nausea/vomiting	3.1	8.5	0.2747
▪ Abdominal pain	0.7	2.4	0.3838
▪ Volume overload	0	0	Not applicable
▪ Aspiration pneumonia	0	0	Not applicable
▪ Hemorrhagic shock	0.1	1.9	0.0704
▪ Exacerbation bleeding	36.7	28.4	0.3594
▪ Ileus	0	0	Not applicable
▪ Colonoscopy-related adverse events	0.5	0	Not applicable
▪ Hemorrhagic shock	0.5	0	Not applicable
▪ Perforation	0	0	Not applicable
Serious adverse events			
▪ Acute myocardial infarction	0	2.1	Not applicable
▪ Bacterial cellulitis	0.5	0	Not applicable
Outcome			
▪ Need for additional endoscopic examinations	33.7	26.6	0.4193
▪ Need for interventional radiology	1.4	0	0.3146
▪ Need for surgery	0	0	Not applicable

▶ **Table 4** (Continuation)

Outcomes	Expert, %	Nonexpert, %	P value
▪ Need for transfusion during hospitalization	6.6	6.1	0.908
▪ Length of stay (day)[1]	7.0	6.1	0.1943
▪ 30-day rebleeding	15.7	5.39	0.0792
▪ 30-day thrombosis events	0	2.31	0.3118

SRH, stigmata of recent hemorrhage.
[1] Summarized by mean (and SD).

▶ **Table 5** Endoscopic outcomes, adverse events, and clinical outcomes between expert group and groups with <3-year endoscopic experience.

Outcomes	Expert, (%) N = 96	<3 years, (%) N = 8	P value
Endoscopic outcomes			
▪ Cecum insertion	92 (95.8)	8 (100)	1
▪ Time to the cecum (min), mean ± SD	8.1 ± 5.8	6.8 ± 1.9	0.9949
▪ Total time (min), mean ± SD	32.9 ± 18.9	34.3 ± 9.1	0.3861
▪ SRH identification	23 (24.0)	1 (12.5)	0.3585
Bleeding source by colonoscopy findings			
▪ Diverticular (definite)	16 (16.7)	1 (12.5)	1
▪ Diverticular (presumptive)	41 (42.7)	3 (37.5)	1
▪ Rectal ulcer	0 (0.0)	0 (0.0)	Not applicable
▪ Colorectal cancer	4 (4.2)	0 (0.0)	1
▪ Ischemic colitis	8 (8.3)	2 (25.0)	0.1704
▪ Infectious colitis	0 (0.0)	0 (0.0)	Not applicable
▪ Radiation colitis	1 (1.0)	0 (0.0)	1
▪ Colonic ulcer	0 (0.0)	0 (0.0)	Not applicable
▪ Nonspecific colitis	0 (0.0)	0 (0.0)	Not applicable
▪ Hemorrhoid	3 (3.1)	0 (0.0)	1
▪ Others	11 (11.5)	0 (0.0)	1
▪ Unknown	16 (16.7)	2 (25.0)	0.6245
▪ Upper gastrointestinal bleeding	1 (1.0)	0 (0.0)	1
Success rate of endoscopic treatment	19/20 (95.0)	1/1 (100)	0.3049
Completion rate of successful endoscopic treatment without expert assist	Not applicable	8 (100)	Not applicable
Adverse event			
▪ Preparation-related adverse events	33 (34.4)	3 (37.50)	1
▪ Nausea/vomiting	2 (2.1)	1 (12.50)	1
▪ Abdominal pain	1 (1.0)	0 (0.0)	0.2154
▪ Volume overload	0	0 (0.0)	Not applicable
▪ Aspiration pneumonia	0	0 (0.0)	Not applicable
▪ Hemorrhagic shock	1 (1.0)	0 (0.0)	1

▶ **Table 5** (Continuation)

Outcomes	Expert, (%) N = 96	<3 years, (%) N = 8	P value
Exacerbation bleeding	32 (33.3)	2 (25.0)	1
▪ Ileus	0	0 (0.0)	Not applicable
▪ Colonoscopy related adverse events	1 (1.0)	0 (0.0)	1
▪ Hemorrhagic shock	1 (1.0)	0 (0.0)	1
▪ Perforation	0 (0.0)	0 (0.0)	Not applicable
Serious adverse events			
▪ Acute myocardial infarction	0	0 (0.0)	Not applicable
▪ Bacterial cellulitis	1 (1.0)		1
Outcome			
▪ Need for additional endoscopic examinations	23 (24.0)	1 (12.5)	0.0489
▪ Need for interventional radiology	1 (1.0)	0	0.3148
▪ Need for surgery	0	0	Not applicable
▪ Need for transfusion during hospitalization	6 (6.3)	1 (12.5)	0.605
▪ Length of stay (day)[1]	6.8	5.5	0.0346
▪ 30-day rebleeding	13 (14.3)	0	<0.001
▪ 30-day thrombosis events	0	0	Not applicable
▪ 30-day mortality	0	0	Not applicable

SRH, stigmata of recent hemorrhage.
[1] Summarized by mean (and SD).

▶ **Table 6** Endoscopic outcomes, adverse, events and clinical outcomes in expert group and group with 3 to 6 years of endoscopic experience

Outcomes	Expert, (%) N = 96	3–6 years, (%) N = 32	P value
Endoscopic outcomes			
▪ Cecum insertion	92 (95.8)	31 (96.9)	1
▪ Time to the cecum (min), mean ± SD	8.1±5.8	12.5±8.7	0.0012
▪ Total time (min), mean ± SD	32.9±18.9	33.5±16.0	0.8107
▪ SRH identification	23 (24.0)	5 (15.6)	0.2827
Bleeding source by colonoscopy findings			
▪ Diverticular (definite)	16 (16.7)	5 (15.6)	0.8904
▪ Diverticular (presumptive)	41 (42.7)	18 (56.3)	0.1832
▪ Rectal ulcer	0 (0.0)	0 (0.0)	Not applicable
▪ Colorectal cancer	4 (4.2)	1 (3.1)	1
▪ Ischemic colitis	8 (8.3)	1 (3.1)	0.4487
▪ Infectious colitis	0 (0.0)	1 (3.1)	0.25
▪ Radiation colitis	1 (1.0)	0 (0.0)	1
▪ Colonic ulcer	0 (0.0)	2 (6.3)	0.061
▪ Nonspecific colitis	0 (0.0)	0 (0.0)	Not applicable
▪ Hemorrhoid	3 (3.1)	0 (0.0)	0.5726

▶ **Table 6** (Continuation)

Outcomes	Expert, (%) N = 96	3–6 years, (%) N = 32	P value
▪ Others	11 (11.5)	3 (9.4)	1
▪ Unknown	16 (16.7)	3 (9.4)	0.3997
▪ Upper gastrointestinal bleeding	1 (1.0)	0 (0.0)	1
Success rate of endoscopic treatment	19/20 (95.0)	5/5 (100)	0.3049
Completion rate of successful endoscopic treatment without expert assist	Not applicable	32 (100)	Not applicable
Adverse event			
▪ Preparation-related adverse events	33 (34.4)	3 (37.50)	1
▪ Nausea/vomiting	2 (2.1)	1 (12.50)	1
▪ Abdominal pain	1 (1.0)	0 (0.0)	0.2154
▪ Volume overload	0	0 (0.0)	Not applicable
▪ Aspiration pneumonia	0	0 (0.0)	Not applicable
▪ Hemorrhagic shock	1 (1.0)	0 (0.0)	1
▪ Exacerbation bleeding	32 (33.3)	2 (25.0)	1
▪ Ileus	0	0 (0.0)	Not applicable
▪ Colonoscopy related adverse events	1 (1.0)	0 (0.0)	1
▪ Hemorrhagic shock	1 (1.0)	0 (0.0)	1
▪ Perforation	0 (0.0)	0 (0.0)	Not applicable
Serious adverse events			
▪ Acute myocardial infarction	0	1 (3.1)	0.25
▪ Bacterial cellulitis	1 (1.0)	0 (0.0)	1
Outcome			
▪ Need for additional endoscopic examinations	36 (37.5)	9 (28.1)	0.3165
▪ Need for interventional radiology	1 (1.0)	0	0.3148
▪ Need for surgery	0	0	Not applicable
▪ Need for transfusion during hospitalization	6 (6.3)	0	0.0114
▪ Length of stay (day)[1]	6.8	6.6	0.1593
▪ 30-day rebleeding	13 (14.3)	1 (3.1)	0.0197
▪ 30-day thrombosis events	0	1 (3.1)	0.3096
▪ 30-day mortality	0	0	Not applicable

SRH, stigmata of recent hemorrhage.
[1] Summarized by mean (and SD).

pert group performed much more challenging procedures. Third, there are no standardized teaching and training programs among the participating hospitals. Fourth, we could not collect data on what kind of technical advice the non-expert endoscopists received, including the selection of the appropriate endoscopy hemostasis device. This advice may have been helpful for successful hemostasis in the non-expert group. Finally, subgroup analysis according to the years of endoscopic experience included a small population and did not reach adequate statistical power.

Conclusions

In summary, we found that the performance of colonoscopies for ALGIB by nonexpert endoscopists did not yield worse clinical outcomes or reduced safety, suggesting that colonoscopy for ALGIB may be a feasible advanced procedure for nonexpert endoscopists to perform.

Acknowledgements

Competing interests

The authors declare that they have no conflict of interest.

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