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Prolonged video capsule endoscopy examination durations can improve capsule endoscopy completeness

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Abstract

Background Capsule endoscopy (CE) is useful for managing patients with suspected small bowel diseases. However, the effect of prolonged CE examination time on CE performance is unknown.

Aim To evaluate the completeness and diagnostic yield of prolonged CE imaging in patients with suspected small bowel bleeding.

Methods We reviewed consecutive records of adult CE examinations via an overnight protocol from Jan 2016 to Dec 2020 at a tertiary center in Taiwan. We subcategorized the CE records by recording length into within 8 h, within 12 h and throughout the whole procedure and compared the completion rate and diagnostic yield between the groups. Cochran's Q test was used for statistical analysis.

Results A total of 88 patients were enrolled with 78.4% inpatients (median age 72 years). The small bowel evaluation completion rate was 93.2%, which was significantly greater than the 79.5% rate within 12 h ($p = 0.025$) and the 58% rate within 8 h ($p < 0.001$). The diagnostic yield was 83% in the whole-course overnight study, which was significantly greater than the 71.6% diagnostic yield within 8 h ($p < 0.001$) and similar to the 81.8% diagnostic yield within 12 h.

Conclusion Prolonged overnight CE examination can improve the completion rate and diagnostic yield and should be considered for routine clinical practice.

Keywords Capsule endoscopy, Completion rate, Diagnostic yield, Suspected small bowel bleeding

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Introduction

Capsule endoscopy (CE) is a noninvasive method for visualizing the small bowel mucosa and has been used for patients with suspected small bowel diseases, including small bowel bleeding, polyps, Crohn's disease, and celiac disease [1–3].

The diagnostic yield of CE for small bowel lesions is high [4], and CE has been shown to be superior to conventional diagnostic techniques, such as barium radiography, computed tomography (CT) enterography and conventional angiography [5]. The diagnostic yields of CE and balloon-assisted endoscopy are also comparable in patients with suspected small bowel diseases [6].

Suspected small bowel bleeding is the most common indication for CE in clinical practice [4, 7]. Small bowel bleeding accounts for approximately 5–10% of all gastrointestinal bleeding [8]. Suspected small bowel bleeding can be overt and can present with melena or hematochezia, or occult bleeding that presents [2] as a positive fecal occult blood test result or iron deficiency anemia with negative results from upper and lower gastrointestinal tract endoscopy [9]. In patients with suspected small bowel bleeding, CE has a greater diagnostic yield for identifying a bleeding source than push enteroscopy and small bowel barium radiography [10]. The overall sensitivity and specificity of CT enterography for the diagnosis of suspected small bowel bleeding were 72.4% and 75.2%, respectively, according to a recently published consensus by the American College of Gastroenterology and Society of Abdominal Radiology, but the patients presented with both overt and occult GI bleeding [11]. In a recent meta-analysis, CE had a higher sensitivity 0.74 (95% CI: 0.61–0.83) versus 0.47 (95% CI: 0.32–0.62) for CT enterography, whereas CT enterography had a significantly higher specificity 0.94 (95% CI: 0.64–0.99) versus 0.53 (95% CI: 0.36–0.69) for CE [12]. The diagnostic yield of CE exceeds that of CT enterography in another meta-analysis [13] Therefore, CE is recommended as the test of choice for patients with obscure gastrointestinal bleeding [2, 3, 8].

Since the first introduction of CEs in 2000 [14], several different models of CEs have been developed [15, 16]. No significant differences in diagnostic yield were found between the different models of CEs in one meta-analysis [17]. CE technology has also evolved in the last decade. The new generation of capsule endoscopes has better image resolution, wider viewing angles, higher rates of image capture and a longer battery life, which has increased from 8 h to 12 h or longer [18]. A longer operating time may improve the capsule endoscopy completion rate; however, limited data exist, and the results are inconclusive. The CE completion rate of the PillCam SB2 ex (Given Imaging, Yoqneam, Israel) was found to be significantly greater than that of the PillCam SB2 (Given Imaging, Yoqneam, Israel) in a United States study [19] but was not significantly different in another Canadian study [20]. The CE completion rate also did not differ between the newer generation CE PillCam SB3 (Medtronic, Minneapolis, MN, United States) and PillCamSB2 [21, 22]. The capsule endoscopy protocols used were not well defined; patients may still receive capsule endoscopy examinations from 8 AM to 5 PM, as usual, regardless of the benefit of a longer battery life span. The effect of increasing recording time on diagnostic yield was also inconclusive [19–22]. An Olympus Endocapsule 10 (Olympus Corp., Tokyo, Japan) is a new generation of CE with a longer battery life span of at least 12 h, and it may reach 20 h. We started an overnight CE protocol after the introduction of this newer model of CE in our hospital. The aim of this study was to evaluate the effects of prolonged recording time on the completion rate and diagnostic yield using an Olympus Endocapsule 10. We hypothesized that a longer operating time can lead to a more complete examination and greater diagnostic yield.

Materials and methods

Patient selection and capsule endoscopy protocol

We retrospectively reviewed the CE records from January 2013 to December 2020 at Taipei Veterans General Hospital. Consecutive adult patients (aged ≥ 20 years) receiving overnight CE with the Olympus Endocoapsule 10 due to suspected small bowel bleeding were enrolled in this study. Bowel preparation with 2 L of polyethylene glycol followed by 2 L of water was given at night (for the morning exam) or in the early morning (for the afternoon exam) before the CE examination.

Some patients were exempt from receiving bowel preparation due to the need for urgent examinations to quickly identify bleeding sources. Others were medically unsuitable for such preparation, especially those at risk from consuming large volumes of fluids, like individuals undergoing hemodialysis. Additionally, personal unwillingness to take polyethylene glycol also led to exemptions. The patient received 10 ml of simethicone preparation 15 min prior to the CE exam. For the overnight CE examination, the patients swallowed the Olympus Endocoapsule 10 CE in the morning or afternoon. The CE location was checked 2 h after the ingestion via capsule endoscopy. If the capsule endoscope did not enter the small bowel, the patient was instructed to do some walking, get some exercise, and drink a little water. If the CE did not reach the small bowel within 4 h, 10 mg of domperidone was given orally. The patients were permitted to restart clear liquid fluid and solid food 4 h and 6 h later. The CE recording continued until the patient returned to the clinic. For some inpatients with active bleeding, CE was checked at least after 12 h at midnight. If colon arrival was confirmed during

real-time monitoring, the CE recording was stopped. All CE results were read by one of the two experienced gastroenterologists.

Data collection

The patients' medical records, including age, sex, comorbidities, associated medications (antiplatelet and anticoagulant agents, nonsteroidal anti-inflammatory drugs), suspected small bowel bleeding, other diagnostic examinations, therapeutic interventions, length of hospital stay, rebleeding and death, were reviewed to obtain demographic and clinical data up to December 31, 2020. We calculated the Charlson comorbidity index (CCI) and categorized the patients into three grades: mild, with a CCI≤2; moderate, with a CCI of 3–4; and severe, with a CCI≥5. Suspected small bowel bleeding was further categorized into occult obscure gastrointestinal bleeding (positive fecal occult blood test result or iron deficiency anemia) or overt obscure gastrointestinal bleeding (visible gastrointestinal bleeding and presenting in the form of melena or hematochezia). The patients' CE records were also reviewed, including the capsule endoscope model, indications for CE, study length, gastric transit time, small bowel transit time, study completion, capsule endoscopy findings, timestamps of most distant findings, lesions detected within 8 h, lesions detected beyond 8–12 h, bowel cleansing quality and complications.

A complete CE was defined as a capsule that had reached the cecum within the recording time. The CE completion rate was evaluated according to the recording length, including the completion rate within 8 h of recording length, within 12 h of recording length and throughout the whole recording length (see Supplementary Fig. 1). The diagnostic yield on CE was defined as a clinically relevant lesion according to Saurin's classification. (a) P1 and P2 lesions were defined as positive findings and included vascular disease (i.e., arteriovenous malformation and angioectasia), small bowel ulceration or erosion, bleeding of unknown origin, diverticulum, polyp and tumor; (b) P0 lesions were defined as negative findings [23].

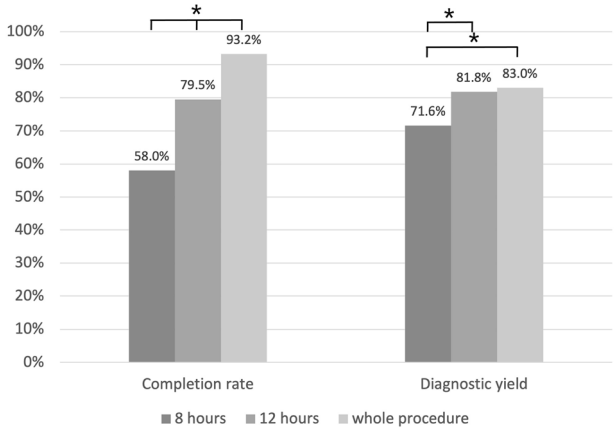

Fig. 1 Completion rate of capsule endoscopy examination within 8 h of recording length ($n=88$), within 12 h of recording length and throughout the whole recording length (*: $p<0.05$). Diagnostic yield of capsule endoscopy within 8 h of recording length ($n=88$), within 12 h of recording length and throughout the whole recording length (*: $p<0.05$)

Statistical analysis

For statistical analysis, continuous variables are presented as the means and standard deviations for descriptive statistics and were compared using Student's t test or the Mann–Whitney test, whereas categorical variables are presented as proportions for descriptive statistics and were compared using the χ2 test or Fisher's exact test. The Cochran's Q test was used for comparisons of the completion rate and the diagnostic yield within 8 h of recording length and within 12 h of recording length and of the whole recording length. To identify possible factors influencing the completion rate and diagnostic yield of CE examinations, all potential associated factors were examined by univariate binary logistic regression analysis. After determining relevant factors with $P<0.1$ in univariate analyses, multivariate regression analysis was performed using logistic regression analysis. P values less than 0.05 were considered to indicate statistical significance. All the statistical analyses were performed using SPSS version 20 (SPSS, Inc., Chicago, IL, U.S.A.).

Results

Study population

A total of 141 patients underwent capsule endoscopy during the study period. Twenty-one patients were excluded due to the use of other capsule endoscopy models, 28 patients were excluded due to indications other than suspected small bowel bleeding, and 4 patients were excluded due to age<20 years. Eighty-eight patients were enrolled in the subsequent analysis. The median age of the patients was 72 years (range 25–90), 63.6% were elderly, and 44.3% were female (Table 1). Bowel preparation (2 L of polyethylene glycol) was administered to 50.0% of patients prior to CE.

Indications for performing CE were suspected overt small bowel bleeding ($n=80$; 90.9%) and suspected occult small bowel bleeding ($n=8$; 9.1%). The median follow-up period was 12.2 (range 0.0-47.3) months after CE examination. Most of the patients received additional diagnostic examinations, which included abdominal CT ($n=79$; 89.8%), small-bowel X-ray ($n=7$; 8.0%), RBC scan ($n=41$; 46.6%), and angiography ($n=9$; 10.2%).

CE completeness

The CE completion rate was evaluated according to the recording length. The small bowel was completely examined within 8 h of the recording length in 51 patients

Table 1 Demographic characteristics of patients who underwent complete or incomplete CE procedures

Demographic characteristics, *n* (%)	Total (n = 88)	Complete CE (*n* = 82)	Incomplete CE (*n* = 6)	P value
Age, years (median, range)	72(25–90)	68(25–90)	77(68–90)	0.09
Elderly	56(63.6)	50(61.0)	6(100)	
Gender				0.547
Male	49(55.7)	46(56.1)	3(50.0)	
Female	39(44.3)	36(43.9)	3(50.0)	
Clinical manifestations and bleeding characteristics				
Melena	64(72.7)	59(72)	5(83.3)	0.546
Hematochezia	27(30.7)	25(30.5)	2(33.3)	0.884
Iron deficiency anemia	35(39.7)	31(37.8)	4(66.7)	0.163
Shock	18(20.5)	17(20.7)	1(16.7)	0.644
Stool OB EIA				0.231
Negative	20(22.7)	17(20.7)	3(50.0)	
positive	14(16.0)	13(15.9)	1(16.7)	
Stool OB (Guaiac test)				0.004
Negative	8(9.1)	8(9.8)	0(0.0)	
Positive	67(76.1)	61(74.4)	6(100)	
Hemoglobin (median, range)	7.7(3.1–15.9)	7.7(3.1–15.9)	8.2(5.7–9.4)	0.860
aPTT (median, range)	29.9(15.2–47.3)	29.6(15.2–47.3)	32.4(25.4–35.9)	0.729
Platelet (median, range)	182000.0(37000–806000)	182000.0(37000–806000)	227500.0(88000–503000)	0.342
PT/INR (median, range)	1.09(0.9–2.5)	1.1(0.9–2.5)	1.1(1.03–1.25)	0.812
Blood transfusion (Unit)	10.7	11	5.8	0.527
Concomitant medication				
Anticoagulant	13(14.8)	11(13.4)	2(33.3)	0.214
Antiplatelet	9(10.2)	7(8.5)	2(33.3)	0.113
NSAIDs	5(5.7)	4(4.9)	1(16.7)	0.304
Laxatives	44(50.0)	43(52.4)	1(16.7)	0.101
Comorbidity				
Charlson comorbidity index (median, range)	4(0–11)	4(0–11)	6(2–11)	0.124
Mild	27(30.7)	26(31.7)	1(16.7)	
Moderate	23(26.1)	23(28.0)	0(0)	
Severe	38(43.2)	33(40.2)	5(83.3)	
Valvular heart disease	6(6.8)	5(6.1)	1(16.7)	0.327
Arrhythmia	13(14.8)	13(15.9)	0(0)	< 0.001
Hypertension	48(54.5)	45(54.8)	3(50.0)	0.571
Ischemic heart disease	17(19.3)	15(18.3)	2(33.3)	0.327
Diabetes Mellitus	34(38.6)	31(37.8)	3(50.0)	0.427
Chronic obstructive Pulmonary disease	6(6.8)	5(6.1)	1(16.7)	0.354
Malignancy	17(19.3)	11(13.4)	2(50.0)	0.164
Chronic kidney disease	25(28.4)	24(29.3)	1(16.7)	0.514
Old cerebrovascular accident	10(11.4)	9(11.0)	1(16.7)	0.526
Chronic liver disease	10(11.4)	9(11.0)	1(16.7)	0.676
Peptic ulcer	8(9.2)	7(8.5)	1(16.7)	0.450
Previous GI tract surgery	2(2.3)	2(2.4)	0(0.0)	0.868
Autoimmune disease	5(5.7)	5(6.1)	0(0.0)	0.696
Prior diagnostic examinations				
CT/MRE	79(89.8)	74(90.2)	5(83.3)	0.247
Small bowel X-ray	7(8.0)	6(7.4)	1(16.7)	0.420
RBC scan	41(46.6)	37(45.1)	4(66.7)	0.489
Angiographic embolization	9(10.2)	9(11.0)	0(0.0)	0.398

(58%), within 12 h of the recording length in 70 patients (79.5%), and throughout the whole recording length in 82 patients (93.2%). Compared to those of the 8-hour and 12-hour CE recording lengths, the whole CE recording length significantly increased the completion rate. ($p<0.001$, $p=0.025$) (Fig. 1).

The demographic characteristics of patients who underwent complete or incomplete CE procedures are shown in Table 1. No significant differences were found in most of the demographic or CE characteristics between patients with complete CE and incomplete CE, except that the prevalence of complete CE was significantly greater than that of incomplete CE in patients with a stool OB (Guaiac test, $p=0.004$) or arrhythmia ($p<0.001$). The clinical outcomes for patients who underwent complete or incomplete CE procedures are shown in Table 2. No differences in death, rebleeding or hospital stay length were observed between patients with complete CE and incomplete CE. The characteristics of patients with complete and incomplete CE procedures are shown in Table 3. Only the small bowel transit time was longer in patients with incomplete CE studies than in patients with complete CE studies ($p<0.001$).

Predictive factor analysis for complete CE

According to the univariate logistic regression analysis of predictive factors for complete CE procedures, the Charlson comorbidity index and malignancy score were significantly greater in patients with complete CE ($p=0.033$ and 0.034, respectively) (Table 4). Complete CE was not associated with other predictive factors, including the use of NSAIDs, anticoagulation therapy or antiplatelet therapy. According to the multivariate logistic regression analysis of predictive factors for complete CE procedures, no predictive factor for complete CE was identified.

Diagnostic yield

Seventy-three patients (83%) had a positive CE, including findings such as small bowel P1 lesions ($n=16$; 18.2%) and P2 lesions ($n=57$; 64.8%). The positive CE findings were evaluated according to the recording length. Clinically relevant lesions were found within 8 h of the recording length in 63 patients (71.6%), within 12 h of the recording length in 72 patients (81.8%), and throughout the whole recording length in 73 patients (83%). Compared to those of the 8-hour recording length, the 12-hour recording length and whole CE recording length significantly increased the diagnostic yield. ($p<0.001$) (Fig. 1). The patient characteristics and CE findings are shown in Table 3. The most common CE findings were angioectasia(s) ($n=34$; 38.6%), followed by ulcer(s)/erosion(s) ($n=32$; 36.4%), lymphangiectasia or xanthoma ($n=5$; 5.7%), diverticulum ($n=4$; 4.5%), gastric bleeding ($n=3$; 3.4%), colonic bleeding ($n=3$; 3.4%), and tumor ($n=3$; 3.4%), and no abnormalities ($n=4$; 4.5%).

Discussion

To our knowledge, this is the first study aimed at evaluating the effects of a prolonged monitoring time on the completion rate and diagnostic yield using the Olympus Endocapsule 10. We found that the completion rate of whole recording length was significantly greater for within 8 h of recording length and within 12 h of recording length. The percentage of patients with a completion rate within 12 h of recording length was also significantly greater than that with an 8-hour recording length. Moreover, we demonstrated an improved diagnostic yield for the whole recording length over 8 h of recording length. A prolonged capsule endoscopy time was related to a higher capsule endoscopy completion rate and diagnostic yield.

Theoretically, the advancement of a longer battery life span should improve the completion rate of CE; however, the effectiveness of a longer operating time in improving completion rates was uncertain in previous studies. (19–22) In this study, we confirmed that an additional 4 h of operating time provided by the 12-hour recording length Endocapsule 10 resulted in a significantly greater completion rate than the 8-hour recording length. Extending the examination time beyond 12 h by using the whole-course overnight protocol resulted in the highest completion rate, which was also significantly greater than that of both the 12-hour and 8-hour recording lengths. In our study, more patients were inpatients, which may be related to the relatively low 8-hour completion rate compared with that in previous studies.(24) However, using a whole-course overnight protocol in CEs can overcome the potential shortcomings of inpatients in terms of CE completeness.

In our study, 6 CE studies were not completed, and 5 were still found in the small bowel 16 to 18 h later. The lack of completion of these 5 CE studies may be due to slow bowel motility. The remaining case was incomplete due to retention in gastric anastomoses. The results of

Table 2 Clinical outcomes for complete and incomplete CE procedures

Demographic characteristics, *n* (%)	Total ($n=88$)	Complete CE ($n=82$)	Incomplete CE ($n=6$)	*P* value
Death	17 (19.3)	16(19.5)	1(16.7)	0.673
Rebleeding	21(23.9)	19(23.2)	2(33.3)	0.442
Hospital stay length	13.0(0-386)	13.0(0-386)	13.5(5–58)	0.728
Follow-up days (median, range)	367 (1-1420)	352(1-1420)	669(275–876)	0.643

Table 3 Complete and incomplete CE procedure characteristics

Demographic characteristics, *n* (%)	Total (*n* = 88)	Complete CE (*n* = 82)	Incomplete CE (*n* = 6)	*P* value
Inpatients (admission)	69(78.4)	63(76.8)	6(100.0)	0.221
Indication				0.428
Suspected overt SB bleeding	80(90.9)	74(90.2)	6(100)	
Suspected occult SB bleeding	8(9.1)	8(9.8)	0(0.0)	
P class (small bowel)				0.469
P0	15(17.0)	14(17.1)	1(16.7)	
P1	16(18.2)	16(19.5)	0(0.0)	
P2	57(64.8)	52(63.4)	5(83.3)	
P class (all)				0.279
P0	10(11.4)	10(12.2)	0(0.0)	
P1	15(17.0)	15(18.3)	0(0.0)	
P2	63(71.6)	57(69.5)	6(100.0)	
Result				0.522
Normal	4(4.5)	4(4.9)	0(0.0)	
Ulcers/erosion	32(36.4)	28(34.1)	4(66.7)	
Angioectasia	34(38.6)	33(40.2)	1(16.7)	
Malignant or benign tumor	3(3.4)	3(3.6)	0(0.0)	
Diverticulum	4(4.5)	4(4.9)	0(0.0)	
Gastric bleeding	3(3.4)	2(2.4)	1(16.7)	
Colonic bleeding	3(3.4)	3(3.7)	0(0.0)	
Lymphangectasia or xanthoma	5(5.7)	5(6.1)	0(0.0)	
Endoscopic delivery of CE	23(26.1)	20(24.4)	3(50.0)	0.181
Gastric transit time	16(0-369)	16(0-369)	140(0-180)	0.151
Small bowel transit time	361(91-1134)	339(91-1122)	1035(811–1134)	< 0.001
Total exam time	1033(452–1273)	1031(452–1203)	1035(972–1273)	0.158
Capsule retention	1(1.1)	0(0.0)	1(16.7)	0.363
Cleansing quality				0.223
Excellent	0(0.0)	0(0.0)	0(0.0)	
Good	60(68.2)	57(69.5)	3(50.0)	
Fair	20(22.7)	17(20.7)	3(50.0)	
Poor	8(9.1)	8(9.8)	0(0.0)	
Subsequent treatment				0.081
Medical treatment	48(54.5)	47(57.3)	1(16.7)	
Endoscopic treatment	35(39.8)	31(37.8)	4(66.7)	
Surgery	3(3.4)	2(2.4)	1(16.7)	
Angiographic embolization	2(2.3)	2(2.4)	0(0.0)	

our study suggest that outpatient capsule endoscopy leads to a greater completion rate of small bowel examinations, as indicated by the significantly greater percentage of complete studies than inpatient capsule endoscopy (100.0% vs. 91.3%, $P=0.013$), supporting that previously reported inpatient capsule endoscopy frequently leads to incomplete small bowel examinations. The severity of illness and sedentary status may contribute to incomplete exams [24]. Besides, one animal study has shown that smaller capsule endoscopes significantly shorten gastric transit times without impacting small bowel transit times [25]. Notably, a comparative study found that miniaturized capsules (9.5×24.5 mm) not only reduced gastric transit time to 49.4 min from 66.2 min but also extended small-bowel transit time to 5.8 h from 5.0 h [26]. These findings indicate that smaller capsules could reduce retention issues and enhance the clinical utility of capsule endoscopy.

In our study, we also observed a significantly greater diagnostic yield for whole-course overnight recordings than for 12-hour and 8-hour recordings. However, previous studies have shown no difference in clinically significant findings between different generations of CE [19–22]. A previous meta-analysis found no significant difference in diagnostic yield between different models of CE, and variations in completion rate or small-bowel transit time did not influence the diagnostic yield [17]. In a recent observational study, a greater number of P1 lesions were identified with newer generation CEs, which were irrelevant to the location of the small bowel lesions [27]. By comparing different recording times of the same CE, our study evaluated the effect of prolonging

Table 4 Univariate logistic regression analysis of predictive factors for complete CE procedures

Characteristics, *n* (%)	Total (*n* = 88)	Complete CE (*n*=82)	Incomplete CE (*n*=6)	OR (95% CI)	*P* value
Age, years (median, range)	72(25-90)	68(25-90)	77(68-90)	0.934 (0.860-1.014)	0.103
Inpatients (admission)	69(78.4)	63(76.8)	6(100.0)	Noncalculable	0.998
Indication				Noncalculable	0.999
Suspected overt SB bleeding	80(90.9)	74(90.2)	6(100)		
Suspected occult SB bleeding	8(9.1)	8(9.8)	0(0.0)		
Clinical manifestations and bleeding characteristics					
Hemoglobin (median, range)	7.7(3.1-15.9)	7.7(3.1-15.9)	8.2(5.7-9.4)	1.031(0.736-1.444)	0.858
Concomitant medication					
Laxative	44(50.0)	43(52.4)	1(16.7)	5.513(0.617-49.275)	0.127
Comorbidity					
Charlson comorbidity index (median, range)	4(0-11)	4(0-11)	6(2-11)	0.723(0.537-0.975)	0.033
P class (small bowel)				0.971(0.105-8.969)	0.980
Negative	15(17.0)	14(17.1)	1(16.7)		
Positive	73(83.0)	68(82.9)	5(83.3)		
Endoscopic delivery of CE	23(26.1)	20(24.4)	3(50.0)	0.323(0.060-1.727)	0.186

the recording time and was able to remove confounding variables that contributed to technological advancement, including the field of view, image capture quality, and rate of image capture. Unlike in previous studies, in the present study, the diagnostic yield significantly increased with additional recording time, and the increased diagnostic yield may be relevant to the location of small bowel lesions. The predictive factors for complete and positive CE findings were evaluated by using univariate and multivariate analyses in our current study. No specific factor was identified to predict complete or positive CE findings, which has significant implications for the generalized patient population, who can benefit from a prolonged recording time regardless of hospitalization status, disease severity, or underlying comorbidities.

Several limitations exist in our study. This was a retrospective observational and single-center study. The number of enrolled patients was relatively small due to COVID-19 interference. One potential limitation is the malfunction of sensing systems during extended examinations, which could result in incomplete diagnostic CE exams. Although our study did not detect any device damage or adverse events related to sensing system malfunctions, the risk of encountering such issues remains when extended CE examinations are employed over the long term. A study that utilized the FDA's Manufacturer and User Facility Device Experience (MAUDE) database reported malfunction-related adverse events for capsule endoscopy systems in China. These included incomplete videos, recorder failures, and download issues. Specific failures noted were frozen recorders, power outages, and the inability to receive images from the capsule endoscope. However, the exact causes of these malfunctions have not been clearly identified [28]. Finally, only Endocapsule 10 was used in this study, and whether the diagnostic yield can be increased with additional recording time is still uncertain when other commercially available CEs are used.

In conclusion, we found that a prolonged CE examination via an overnight capsule endoscopy protocol can improve the CE completion rate and diagnostic yield, even for inpatients and patients with more comorbidities. Extending the capsule endoscopy examination time should be considered in the clinical management of patients with suspected small bowel bleeding. Further prospective studies using other available commercial CEs may be encouraged to confirm the advantage of longer recording times in capsule endoscopy.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12876-024-03423-4.

Supplementary Material 1

Author contributions

KL, YP, and LC conceived and designed the paper. KS, YY, PW collected and analyzed the data. KL performed the statistical analysis, interpreted the results and drafted the manuscript. KS, YY, PW and TC assisted in the acquisition of the data. LJ, YW, HM and LC supervised the conduct of the whole study. YP obtained funding. All authors read and approved the final version of the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval
The study was approved by the Institutional Review Board of Taipei Veterans General Hospital (IRB/REC 2021-08-001CC). The need for consent to participate was waived by the Institutional Review Board of Taipei Veterans General Hospital. This manuscript has not been previously published and is not being concurrently submitted

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interest.

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