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Original Article

Discordance Rate and Risk Factor of Other Diagnostic Modalities for Small Bowel Tumors Detected by Device-Assisted Enteroscopy: A Korean Association for the Study of Intestinal Disease (KASID) Multicenter Study

Jihye Park[1,2], Jin Su Kim[3], Joo Hye Song[4], Kwangwoo Nam[5], Seong-Eun Kim[6], Eui Sun Jeong[6], Jae Hyun Kim[7], Seong Ran Jeon[8]

[1]Department of Internal Medicine and [2]Institute of Gastroenterology, Severance Hospital, Yonsei University College of Medicine, Seoul, Korea; [3]Department of Internal Medicine, Eunpyeong St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea; [4]Department of Internal Medicine, Konkuk University Medical Center, Konkuk University School of Medicine, Seoul, Korea; [5]Department of Gastroenterology, Dankook University Hospital, Dankook University College of Medicine, Cheonan, Korea; [6]Department of Internal Medicine, Ewha Womans University College of Medicine, Seoul, Korea; [7]Department of Internal Medicine, Kosin University College of Medicine, Busan, Korea; [8]Institute for Digestive Research, Digestive Disease Center, Soonchunhyang University College of Medicine, Seoul, Korea

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Corresponding Author

Seong Ran Jeon
ORCID https://orcid.org/0000-0001-6970-9737
E-mail srjeon@schmc.ac.kr

Jihye Park and Jin Su Kim contributed equally to this work as first authors.

Background/Aims: Despite advances in imaging and endoscopic technology, diagnostic modalities for small bowel tumors are simultaneously performed. We investigated the discrepancy rate between each modality and predictive factors of discrepancy in patients with definite small bowel tumors.

Methods: Data of patients with definite small bowel tumors who underwent both device-assisted enteroscopy (DAE) and computed tomography (CT) were retrieved from web-based enteroscopy registry database in Korea. Predictive risk factors associated with discrepancy were analyzed using logistic regression analysis.

Results: Among 998 patients, 210 (21.0%) were diagnosed with small bowel tumor using DAE, in 193 patients with definite small bowel tumor, DAE and CT were performed. Of these patients, 12 (6.2%) showed discrepancy between examinations. Among 49 patients who underwent DAE and video capsule endoscopy (VCE) examination, 13 (26.5%) showed discrepancy between examinations. No significant independent risk factors were associated with concordance between DAE and CT in multivariate logistic regression analysis among the patients. In a multivariate logistic regression analysis, red blood cell transfusion was negatively associated with concordance between DAE and VCE in patients with small bowel tumor (odds ratio, 0.163; 95% confidence interval, 0.026 to 1.004; p=0.050).

Conclusions: For small bowel tumors, the discrepancy rate between DAE and CT was 6.2%, and 26.5% between DAE and VCE. Despite developments in cross-sectional imaging (VCE and DAE modalities), discrepancies still exist. For small bowel bleeding that require significant transfusion while showing insignificant VCE findings, DAE should be considered as the next diagnostic approach, considering the possibility of missed small bowel tumor. **(Gut Liver 2024;18:686-694)**

Key Words: Balloon enteroscopy; Tomography, X-ray computed; Capsule endoscopy; Neoplasms

INTRODUCTION

Small bowel tumors are very rare, and they account for 1% to 3% of all gastrointestinal neoplasms.[1] The rapid transit time of the small bowel and its liquid contents, which reduce the exposure of ingested carcinogen to its mucosa, relative sterility of the small bowel compared to that of the colon, and its intrinsic protective immune system

could explain the extremely low frequency of small bowel tumors.[2] The diagnosis of small bowel tumors is often challenging, owing to their rarity and non-specific clinical features.[3] Moreover, majority of patients with small bowel tumors are asymptomatic or present with only non-specific symptoms when they have advanced disease.[4,5] Additionally, poor accessibility of the small bowel due to very long anatomical structure (600 to 700 cm) and inaccessibility of the diagnostic modalities also contribute to the difficulty in diagnosing small bowel tumors.[6] Nevertheless, the incidence of these tumors has been increasing in the last few decades, thereby keeping pace with remarkable advances in diagnostic modalities.[7]

Various diagnostic modalities, including cross-sectional imaging and endoscopy, are simultaneously performed in patients suspected of having small bowel tumors; this is because a definite diagnosis is difficult with a single diagnostic method.[8] Cross-sectional imaging modalities, including computed tomography (CT) and magnetic resonance imaging, play a central role in the diagnosis of small bowel tumors because they allow visualization of the entire gastrointestinal tract, as well as extramural lesions.[9] Additionally, video capsule endoscopy (VCE), which is the first line diagnostic modality for small bowel bleeding, may aid in the diagnosis of small bowel tumors, although missing rates and capsule retention must be carefully considered.[10,11] Device-assisted enteroscopy (DAE) allows clinicians to directly visualize small bowel tumors, identify their extent and location, obtain tissue samples, and perform therapeutic interventions.[12,13] DAE is an effective diagnostic and therapeutic method, but it is more labor intensive, requires experienced endoscopists and is difficult to evaluate the entire small bowel. Despite advances in imaging and endoscopic technology, discrepancy in diagnosis occurs for each modality. Depending on the characteristics of the diagnostic modality, this is an inevitable event.

In this study, we aimed to determine the discrepancy rates between DAE and CT, and between DAE and VCE for small bowel tumors confirmed by DAE. Additionally, we analyzed the risk factors associated with concordance rates between DAE and CT, and between DAE and VCE for small bowel tumors.

MATERIALS AND METHODS

1. Patients

This retrospective, multicenter cohort study was conducted using database of the Korean Association for the Study of Intestinal Disease web-based enteroscopy registry (https://enteroscopy.inforang.com/intro/intro.html) from 30 medical centers in South Korea between October 2015 and June 2023. Data were collected anonymously via standardized electronic case report form and managed in the Small Intestinal Research Group under the Korean Association for the Study of Intestinal Disease. Of 998 patients, 210 (21.0%) were diagnosed with small bowel tumors using DAE. A total of 193 patients diagnosed with definite small bowel tumor and underwent both DAE and CT were included in this study. Of the 193 patients, 49 underwent VCE (Fig. 1). Exclusion criteria were as follows: (1) age <18 years old; (2) no evidence of small bowel tumor in DAE and/or CT; (3) either CT or DAE was not performed; (4) uncertain diagnosis despite various diagnostic modalities;

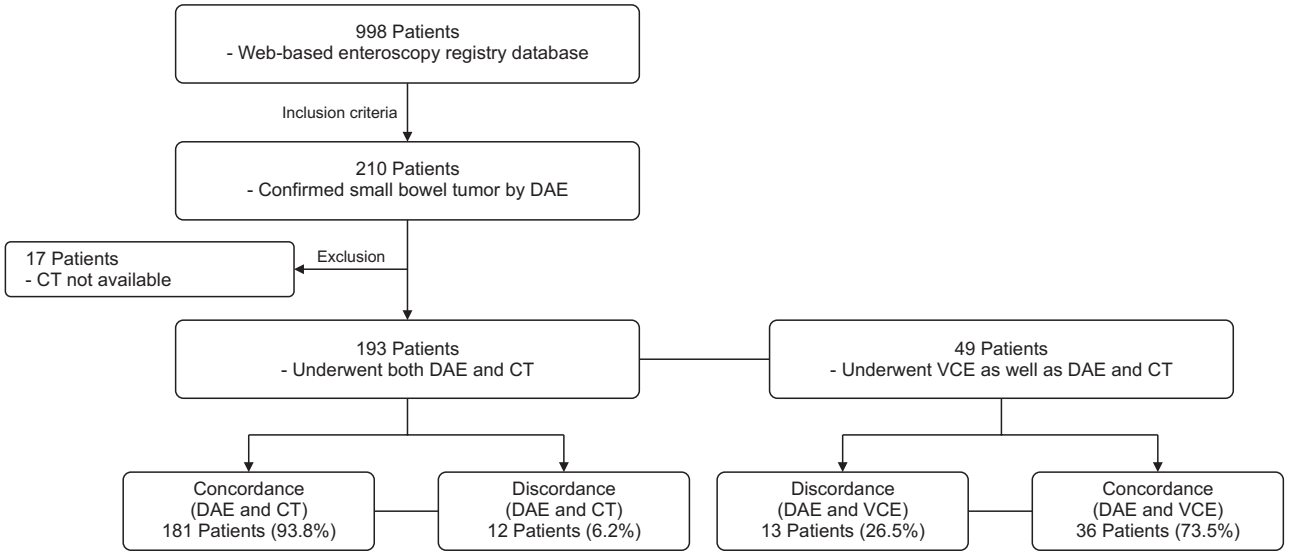

Fig. 1. Enrollment diagram. DAE, device-assisted enteroscopy; CT, computed tomography; VCE, video capsule endoscopy.

or (5) incomplete electronic medical records. The study protocol was approved by the Institutional Review Board and Hospital Research Ethics Committee of each facility (IRB number: 1-2016-0004). Written informed consent was waived.

2. Diagnostic modalities

Double (EN-450P5, T5 or EN-530T; Fujinon Inc., Saitama, Japan) and single (SIF-Q180; Olympus America Inc., Center Valley, PA, USA) balloon enteroscopes, both of which are available in South Korea, were used for enteroscopic examinations. Furthermore, for DAE using the anal approach, the patients underwent bowel preparation with at least 2 L of polyethylene glycol solution the day before the procedure. The route of DAE insertion was determined based on the location of the lesion, according to the results of previous examinations. All procedures were performed in a fluoroscopy unit, with patients undergoing conscious to deep sedation (established by endoscopists), according to each center's sedation protocols. The PillCam SB video (SB1, SB2, and SB3; Given Imaging, Yokneam, Israel) and MiroCam (IntroMedic, Seoul, South Korea) were used for capsule endoscopy. Polyethylene glycol solution (2–4 L) was administered before the examination for cleansing and enhancement of visual clarity. Video findings were interpreted by experienced gastroenterologists at each center. We included all patients that underwent multiphasic CT and CT enterography.

3. Data collection and outcome definitions

The following data were collected from electronic medical records: age, sex, smoking history, alcohol history, Charlson Comorbidity Index, intestinal surgery history, indication of diagnostic test, levels of hemoglobin, albumin, transfusion of red blood cell (RBC), and the size, number, location, and final diagnosis of small bowel tumors. The Charlson Comorbidity Index was used for the assessment of comorbidity level.[14]

The small bowel tumors that were definite on DAE and/or CT were defined, according to the interpretation by experienced gastroenterologists and radiologists. Primary endpoint was discordance rates between DAE and CT, and between DAE and VCE. A discordance was defined when a small bowel tumor was described in DAE but its presence was not described in CT or VCE. Additionally, in DAE, it was described as a small bowel tumor, but when CT or VCE showed other findings such as ulcers/vascular lesions, it was defined as a discordance. Additionally, secondary endpoint was independent risk factors associated with the discordance between DAE and VCE, and between DAE and CT for small bowel tumors. Additionally, secondary endpoint was independent risk factors associated with the discordance between DAE and VCE, and between DAE and CT for small bowel tumors.

4. Statistical analysis

The mean and standard deviation or median and range were calculated for all continuous variables, as appropriate. Multivariate logistic regression analyses were performed to identify independent factors affecting discordance with adjustment for multiple variables. Variables in univariate analysis, with a p-value of ≤0.05, were included in the multivariate analysis. Moreover, a p-value of ≤0.05 was considered statistically significant. All statistical analyses were performed using Statistical Package for Social Sciences (SPSS version 23.0; SPSS Inc., Armonk, NY, USA).

RESULTS

1. Baseline characteristics of small bowel tumors

The mean age of diagnosis was 54.3±13.7 years, and 57.5% of the patients were men. Thirty-nine patients (20.2%) and 47 patients (24.5%) had a history of smoking and alcohol consumption, respectively. The mean Charlson Comorbidity Index was 0.7±1.2, and 45 patients (23.3%) had a history of intestinal surgery. The indication of DAE was abnormal radiologic findings (40.9%), polyposis syndrome (17.6%), overt gastrointestinal bleeding (17.1%), occult gastrointestinal bleeding (2.1%), symptoms, such as abdominal pain, nausea, or vomiting (10.4%), intestinal obstruction (6.7%), and therapeutics (5.2%). The mean hemoglobin level was 11.4±2.6 g/dL, and the mean albumin level was 3.9±0.8 g/dL. Forty patients (20.7%) required RBC transfusion, and the mean volume of RBC was 0.8±2.1 units. Forty-four patients (22.8%) underwent per oral DAE, 141 (73.1%) underwent per anal DAE, and eight (4.1%) underwent both per oral DAE and per anal DAE. Multiphasic CT was performed in 132 (68.4%), and 61 (31.6%) underwent CT enterography. The mean size of the small bowel tumors measured on CT was 25.4±15.2 mm, and 166 patients (85.0%) had single tumor. Locations of the small bowel tumors were the duodenum (10.4%), proximal jejunum (34.2%), mid jejunum (18.7%), distal jejunum (10.9%), proximal ileum (4.7%), mid ileum (4.7%), and distal ileum (15.5%). Final diagnoses of the small bowel tumors were lymphoma (19.7%), hamartoma (18.7%), gastrointestinal stromal tumor (18.1%), ectopic pancreas (11.9%), metastasis (11.4%), lipoma (5.2%), adenocarcinoma (4.7%), benign polyp (3.6%), carcinoid (2.1%), amyloidosis (1.6%), leiomyoma (1.0%), lymphangioma (1.0%), schwannoma (0.5%), and duplication cyst (0.5%).

2. Characteristics and risk factors associated with discordance between DAE and CT of small bowel tumors

Of the 193 patients that underwent DAE and CT examinations, 12 (6.2%) showed discrepancy between the examinations. Male patients were more in number in a discordance group compared to those in a concordance group between DAE and CT (91.7% vs 55.2%, respectively, p=0.015). Furthermore, overt gastrointestinal bleeding was frequent in the discordance group compared to that in the concordance group between DAE and CT (41.7% vs 15.5%, respectively, p=0.035) (Table 1). Carcinoid was frequent in the discordance group compared to that in the concordance group (25.0% vs 0.6%), and amyloidosis was frequent in the discordance group compared to that in the concordance group between DAE and CT (16.7% vs 0.6%) (Table 2). Univariate logistic regression analyses were performed to determine the risk factors associated with the concordance between DAE and CT. Furthermore, female sex was positively associated with the concordance between DAE and CT in patients with small bowel tumors (odds ratio [OR], 8.910; 95% confidence interval [CI], 1.127 to 70.467; p=0.038) (Table 3). Alcohol history (OR, 0.293; 95% CI, 0.090 to 0.957; p=0.042) and overt bleeding (OR, 0.256; 95% CI, 0.076 to 0.865; p=0.028) were negatively associated with the concordance between DAE and CT in patients with small bowel tumor (Table 3). There were no significant independent risk factors in the multivariate regression analysis.

3. Characteristics and risk factors associated with discordance between DAE and VCE of small bowel tumors

Of the 49 patients that underwent DAE and VCE examinations, 13 (26.5%) showed discrepancy between the examinations. The discordance group was older compared to the concordance group between DAE and VCE (57.4 years vs 47.2 years, respectively, p=0.049) (Table 4). Overt gastrointestinal bleeding was frequent (53.8% vs 19.4%, respectively, p=0.031), hemoglobin level was lower (9.6 g/

Table 1. Baseline Characteristics Associated with Discordance between DAE and CT of Small Bowel Tumors

Variable	Total (n=193)	Discordance (n=12)	Concordance (n=181)	p-value*
Age, yr	54.3±13.7	59.4±12.4	54.2±16.6	0.288
Sex				0.015
Male	111 (57.5)	11 (91.7)	100 (55.2)	
Female	82 (42.5)	1 (8.3)	81 (44.8)	
Smoking	39 (20.2)	3 (25.0)	36 (19.9)	0.711
Alcohol	47 (24.4)	6 (50.0)	41 (23.7)	0.074
Charlson Comorbidity Index	0.7±1.2	0.5±1.0	0.7±1.4	0.563
Intestinal surgery history	45 (23.3)	0	45 (24.9)	0.072
Indication of diagnostic test				
Abnormal radiologic images	79 (40.9)	4 (33.3)	75 (41.4)	0.764
Polyposis	34 (17.6)	1 (8.3)	33 (18.2)	0.695
Overt bleeding	33 (17.1)	5 (41.7)	28 (15.5)	0.035
Occult bleeding	4 (2.1)	0	4 (2.2)	1.000
Non-specific symptoms	20 (10.4)	2 (16.7)	18 (9.9)	0.359
Obstruction	13 (6.7)	0	13 (7.2)	1.000
Others (therapeutics)	10 (5.2)	0	10 (5.5)	1.000
Hemoglobin, g/dL	11.4±2.6	10.9±2.7	11.5±2.5	0.448
Albumin, g/dL	3.9±0.8	3.7±0.8	3.9±0.7	0.244
Red blood cell transfusion	40 (20.7)	4 (33.3)	36 (19.9)	0.276
Characteristics of small bowel tumor				
Tumor size, mm	25.4±15.2	25.0±14.0	25.4±17.1	0.947
Single tumor	166 (85.0)	10 (83.3)	156 (86.2)	0.970
Tumor location				0.664
Duodenum	20 (10.4)	1 (8.3)	19 (10.5)	
Proximal jejunum	66 (34.2)	3 (25.0)	63 (34.8)	
Mid jejunum	36 (18.7)	2 (16.7)	34 (18.8)	
Distal jejunum	21 (10.9)	2 (16.7)	19 (10.5)	
Proximal ileum	9 (4.7)	0	9 (5.0)	
Mid ileum	9 (4.7)	0	9 (5.0)	
Distal ileum	30 (15.5)	2 (16.7)	28 (15.5)	

Data are presented as mean±SD or number (%).
DAE, device-assisted enteroscopy; CT, computed tomography.
*p-value for comparing discordance and accordance groups: statistically significant, p<0.05.

dL vs 11.7 g/dL, respectively, p=0.003), albumin level was lower (3.5 g/dL vs 4.1 g/dL, respectively, p=0.007), and RBC transfusion was frequent (69.2% vs 19.4%, respectively, p=0.002) in the discordance group compared to that of the concordance group between DAE and VCE (Table 4). Gastrointestinal stromal tumor was frequent in the discordance group compared to that of the concordance group (61.5% vs 8.3%) between DAE and VCE (Table 5). Univariate logistic regression analyses were performed to determine the risk factors associated with the concordance between DAE and VCE. Overt bleeding (OR, 0.207; 95% CI, 0.053 to 0.812; p=0.024) and RBC transfusion (OR, 0.107; 95% CI, 0.025 to 0.452; p=0.002) were negatively associated with the concordance between DAE and VCE in patients with small bowel tumors (Table 6). Higher albumin level was positively associated with the concordance between DAE and VCE in patient with small bowel tumors (OR, 3.214; 95% CI, 1.201 to 8.603; p=0.020) (Table 6). In the multivariate regression analysis, RBC transfusion was negatively associated with the concordance between DAE and VCE in patients with small bowel tumors (OR, 0.163; 95% CI, 0.026 to 1.004; p=0.050) (Table 6).

Table 2. Final Diagnosis of Small Bowel Tumor According to the Discordance between DAE and CT

Variable	Discordance (n=12)	Concordance (n=181)
Lymphoma	3 (25.0)	35 (19.3)
Hamartoma	0	36 (19.9)
Gastrointestinal stromal tumor	2 (16.7)	33 (18.2)
Ectopic pancreas	0	23 (12.7)
Metastasis	0	22 (12.2)
Lipoma	0	10 (5.5)
Adenocarcinoma	0	9 (5.0)
Benign polyp	2 (16.7)	5 (2.8)
Carcinoid	3 (25.0)	1 (0.6)
Amyloidosis	2 (16.7)	1 (0.6)
Leiomyoma	0	2 (1.1)
Lymphangioma	0	2 (1.1)
Schwannoma	0	1 (0.6)
Duplication cyst	0	1 (0.6)

Data are presented as number (%).
DAE, device-assisted enteroscopy; CT, contrast tomography.

DISCUSSION

This study was conducted with the assumption that despite advances in cross-sectional and VCE imaging, there will still be discrepancies between DAE and other modali-

Table 3. Logistic Regression Analysis for Concordance between DAE and CT in Patients with Small Bower Tumor

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value*	OR (95% CI)	p-value*
Age	0.980 (0.944–1.017)	0.289		
Female sex	8.910 (1.127–70.467)	0.038	5.617 (0.652–48.429)	0.116
Smoking	0.745 (0.192–2.892)	0.670		
Alcohol	0.293 (0.090–0.957)	0.042	0.498 (0.144–1.723)	0.271
Charlson Comorbidity Index (≥2)	1.606 (0.339–7.609)	0.551		
Indication of diagnostic test				
Abnormal radiologic images	1.415 (0.411–4.871)	0.582		
Polyposis	2.453 (0.306–19.664)	0.398		
Overt bleeding	0.256 (0.076–0.865)	0.028	0.396 (0.113–1.394)	0.149
Non-specific symptoms	0.552 (0.112–2.719)	0.465		
Hemoglobin	1.096 (0.865–1.368)	0.447		
Albumin	1.586 (0.728–3.459)	0.246		
Red blood cell transfusion	0.497 (0.142–1.741)	0.274		
Characteristics of small bowel tumor				
Tumor size	1.001 (0.961–1.044)	0.946		
Single tumor	1.062 (0.762–1.480)	0.723		
Tumor location				
Duodenum	1.000 (reference)			
Proximal jejunum	1.105 (1.109–11.253)	0.933		
Mid jejunum	0.895 (0.076–10.528)	0.930		
Distal jejunum	0.500 (0.042–5.990)	0.584		
Proximal ileum	0.999 (NA)	0.999		
Mid ileum	0.237 (0.019–2.968)	0.264		
Distal ileum	0.737 (0.062–8.712)	0.809		

DAE, device-assisted enteroscopy; CT, contrast tomography; OR, odds ratio; CI, confidence interval; NA, not applicable.
*p-value for comparing discordance and accordance groups: statistically significant, p<0.05.

Table 4. Baseline Characteristics Associated with Discordance between DAE and VCE of Small Bowel Tumors

Variable	Total (n=49)	Discordance (n=13)	Concordance (n=36)	p-value*
Age, yr	49.9±15.5	57.4±13.5	47.2±16.2	0.049
Sex				0.333
Male	27 (55.1)	9 (69.2)	18 (50.0)	
Female	22 (44.9)	4 (30.8)	18 (50.0)	
Smoking	7 (14.3)	2 (15.4)	5 (13.9)	1.000
Alcohol	12 (24.5)	2 (15.4)	10 (27.8)	0.474
Charlson's Comorbidity Index	0.5±1.0	0.6±1.1	0.5±0.9	0.657
Intestinal surgery history				
Indication of diagnostic test				
Abnormal radiologic images	11 (22.4)	2 (15.4)	9 (25.0)	0.703
Polyposis	13 (26.5)	1 (7.7)	12 (33.3)	0.140
Overt bleeding	14 (28.6)	7 (53.8)	7 (19.4)	0.031
Occult bleeding	2 (4.1)	2 (15.4)	0	0.066
Non-specific symptoms	4 (8.2)	1 (7.7)	3 (8.3)	1.000
Others (therapeutics)	5 (10.2)	0	5 (13.9)	0.306
Hemoglobin, g/dL	11.1±2.7	9.6±3.0	11.7±2.2	0.003
Albumin, g/dL	3.9±0.7	3.5±1.0	4.1±0.5	0.007
Red blood cell transfusion	16 (32.7)	9 (69.2)	7 (19.4)	0.002
Characteristics of small bowel tumor				
Tumor size, mm	24.0±12.5	30.0±14.4	21.8±10.9	0.107
Single tumor	35 (71.4)	13 (100.0)	22 (66.1)	0.314
Tumor location				0.226
Proximal jejunum	15 (30.6)	3 (23.1)	12 (33.3)	
Mid jejunum	15 (30.6)	6 (46.2)	9 (25.0)	
Distal jejunum	5 (10.2)	2 (15.4)	3 (8.3)	
Proximal ileum	4 (8.1)	2 (15.4)	2 (5.6)	
Mid ileum	5 (10.2)	0	5 (13.9)	
Distal ileum	5 (10.2)	0	5 (13.9)	

Data are presented as mean±SD or number (%).
DAE, device-assisted enteroscopy; VCE, video capsule endoscopy.
*p-value for comparing discordance and accordance groups: statistically significant, p<0.05.

Table 5. Final Diagnosis of Small Bowel Tumor According to the Discordance between DAE and VCE

Variable	Discordance (n=13)	Concordance (n=36)
Hamartoma	0	15 (41.7)
Gastrointestinal stromal tumor	8 (61.5)	3 (8.3)
Lymphoma	1 (7.7)	8 (22.2)
Ectopic pancreas	1 (7.7)	4 (11.1)
Benign polyp	0	2 (5.6)
Lipoma	1 (7.7)	1 (2.8)
Adenocarcinoma	0	1 (2.8)
Carcinoid	1 (7.7)	0
Amyloidosis	0	1 (2.8)
Lymphangioma	1 (7.7)	0
Schwannoma	0	1 (2.8)

Data are presented as number (%).
DAE, device-assisted enteroscopy; VCE, video capsule endoscopy.

ties for small bowel tumors. In fact, the results showed that there was a discordance of 6.2% in DAE and CT, and 26.5% in DAE and VCE. Despite the development of novel techniques, the single diagnostic approach is not sufficient for a definite diagnosis of small bowel tumors.[15] Cross-sectional imaging, DAE, and VCE are the most commonly used techniques for detecting small bowel tumors, and they have complementary advantages and disadvantages, and various optimal sequence of diagnostic techniques could be suggested.[16,17] Therefore, identifying the discrepancy of diagnostic modalities and finding associated factors is of great help in clinical practice.[18]

Cross-sectional imaging, including CT and magnetic resonance imaging, could be recommended for the initial investigation of patients suspected of having small bowel tumors because it is noninvasive, as they can visualize the entire small intestine and surrounding structures.[19,20] Moreover, in clinical settings, CT is the most commonly used cross-sectional imaging. However, CT enterography with luminal distention or magnetic resonance enterography without radiation is preferred for follow-up examination.[16] In patients with suspected small bowel tumors, DAE could be performed for diagnostic purpose to reach histological confirmation by acquisition of biopsy sample and/or therapeutic purposes, such as hemostasis, polypectomy,

Table 6. Logistic Regression Analysis for Concordance between DAE and VCE in Patients with Small Bower Tumor

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value*	OR (95% CI)	p-value*
Age	0.957 (0.914–1.001)	0.057		
Female sex	2.250 (0.585–8.652)	0.238		
Smoking	0.887 (0.150–5.251)	0.895		
Alcohol	2.115 (0.397–11.281)	0.380		
Charlson Comorbidity Index (≥2)	2.897 (0.321–26.158)	0.344		
Indication of diagnostic test				
Abnormal radiologic images	1.833 (0.340–9.886)	0.481		
Polyposis	6.000 (0.696–51.740)	0.103		
Overt bleeding	0.207 (0.053–0.812)	0.024	0.922 (0.141–6.024)	0.932
Non-specific symptoms	1.091 (0.103–11.527)	0.942		
Hemoglobin	1.470 (1.110–1.946)	0.007		
Albumin	3.214 (1.201–8.603)	0.020	2.046 (0.752–5.583)	0.161
Red blood cell transfusion	0.107 (0.025–0.452)	0.002	0.163 (0.026–1.004)	0.050
Characteristics of small bowel tumor				
Tumor size (mm)	0.946 (0.882–1.014)	0.118		
Single tumor	NA (NA)	0.999		
Tumor location				
Proximal jejunum	1.000 (reference)			
Mid jejunum	0.375 (0.073–1.920)	0.239		
Distal jejunum	0.375 (0.042–3.355)	0.380		
Proximal ileum	0.250 (0.024–2.577)	0.244		
Mid ileum	0.999 (NA)	0.999		
Distal ileum	0.999 (NA)	0.999		

DAE, device-assisted enteroscopy; VCE, video capsule endoscopy; OR, odds ratio; CI, confidence interval; NA, not applicable.
*p-value for comparing discordance and accordance groups: statistically significant, p<0.05.

or stent insertion.[21] In our study, the discrepancy rate of small bowel tumors between DAE and CT was 6.2%, and the concordance between DAE and CT was quite high. In a previous study of 68 patients, small bowel tumors were detected in 58 and 61 patients using CT and DAE (discrepancy: 4.4%), respectively, which is similar to those in our study.[22] Additionally, there were no significant risk factors related to the discordance between CT and DAE, including size of small bowel tumors. Nevertheless, cross-sectional imaging may have decreased the sensitivity for small-sized small bowel tumors that are <10 mm, and caution is necessary because the discrepancy between CT and VCE was relatively high for carcinoid and amyloidosis.[23-25] Primary carcinoid tumor in the small bowel is often not visible due to a small size often <10 mm at initial evaluation using CT.[23] Additionally, CT findings of small intestinal amyloidosis are non-specific and diverse.[24,25] Additionally, in our study, patients who had CT but did not have DAE (e.g., cases thought to be small benign lesions) were excluded from the study; therefore, it should be noted that the missing rate in actual CT may be higher.

Regarding VCE, the discrepancy rate between DAE and VCE was 26.5% for small bowel tumors, which is higher than that between DAE and CT. The reason for the discrepancy between DAE and VCE is that VCE itself has some limitations due to relatively high false negative risks and false positive risks.[26,27] Missing rate of VCE for solitary small bowel lesion was 10% to 12% in a previous studies because of rapid transit time in the small bowel, which is dependent on reading mode, lesion type, reader experience, and timing.[28-31] Most of the small bowel tumors missed by VCE were located in the proximal jejunum because of rapid transfer velocity due to bowel peristalsis.[22] Additionally, small bowel tumors cannot be reliably differentiated using VCE because the surface of benign and malignant small bowel tumors are not specific, which requires complementary diagnostic tests, such as DAE.[32,33] In our study, gastrointestinal stromal tumor was frequent in the discordance group between DAE and VCE, and RBC transfusion was associated with discordance between DAE and VCE in patients with small bowel tumor in the multivariate analysis. Zagorowicz *et al.*[34] reported the characteristics of small bowel tumors detected using VCE and identified missed tumors, and of 139 patients, two small bowel gastrointestinal stromal tumors and one mesenteric tumor were missed by VCE, which were found during a follow-up period. In patients with small bowel bleeding, they required transfusion and normal/insignificant VCE, and the risk of missing a tumor in the small bowel can be underestimated.[34] Therefore, DAE should be considered

as the next diagnostic approach when clinical symptoms strongly suggest small bowel bleeding. In summary, VCE itself is affected not only by rapid transition time of the small intestine but also by non-specific characteristics of small intestine tumors, resulting in a relatively high risk of false negative and positive risks. Therefore, clinicians should pay attention to when performing or interpreting VCE and consider DAE in patients with a negative VCE and high clinical suspicion (e.g., small bowel bleeding or unexplained iron deficient anemia).

This is a large multicenter study with enough sample using the Korean Association for the Study of Intestinal Disease web-based enteroscopy registry database from 30 medical centers in South Korea. Additionally, we could analyze the discrepancy rate and risk factors between DAE and CT and between DAE and VCE for small bowel tumors confirmed by DAE. Nevertheless, there are some limitations in our study. First, if DAE is requested due to suspicion of progressive disease, the actual discrepancy rate between DAE and CT may be higher in this study due to selection bias. In addition, since CT is generally taken first and DAE is often performed when abnormality of imaging is detected, selection bias may have occurred, and as a result, the discrepancy rate between DAE and CT may have been evaluated as low. Second, we could not suggest a diagnostic yield for each modality because we enrolled only patients with definite diagnosis of small bowel tumors who underwent DAE and CT. Third, the sample size of patients who underwent DAE and VCE was too small.

In conclusion, our study showed that the discrepancy rate between DAE and CT was 6.2%, and the discrepancy rate between DAE and VCE was 26.5% of small bowel tumors. Despite developments in cross-sectional imaging, including VCE and DAE modalities, discrepancies still exist. In patients with small bowel bleeding who required significant transfusion while showing insignificant VCE findings, DAE should be considered as the next diagnostic approach due to the possibility of missing a diagnosis of small bowel tumor.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTIONS

Conception and design: J.P., J.S.K., S.R.J. Data acquisition: J.S.K., J.H.S., K.N., S.E.K., E.S.J., J.H.K. Data analysis and interpretation: J.P. Drafting of the manuscript: J.P. Critical revision of the manuscript for important intellectual content: S.R.J. Approval of final manuscript: all authors.

ORCID

Jihye Park https://orcid.org/0000-0002-5836-8735
Jin Su Kim https://orcid.org/0000-0002-3397-3189
Joo Hye Song https://orcid.org/0000-0002-1166-0085
Kwangwoo Nam https://orcid.org/0000-0003-3720-9820
Seong-Eun Kim https://orcid.org/0000-0002-6310-5366
Eui Sun Jeong https://orcid.org/0000-0001-8569-9380
Jae Hyun Kim https://orcid.org/0000-0002-4272-8003
Seong Ran Jeon https://orcid.org/0000-0001-6970-9737

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