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Safety and efficacy of simultaneous colorectal ESD for large synchronous colorectal lesions

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ABSTRACT

Background and study aims Multiple large colorectal lesions are sometimes diagnosed during colonoscopy. However, there have been no investigations of the feasibility of simultaneous endoscopic submucosal dissection (ESD) for multiple lesions. This study aims to reveal the strategy of simultaneous ESD for multiple large colorectal lesions.

Patients and methods 246 patients who underwent ESD for 274 colorectal lesions were retrospectively evaluated in this study. Fifty-one large colorectal lesions among 23 patients were treated by ESD simultaneously (simultaneous group), and 223 patients were treated with ESD for a single lesion (single group).

Results En-bloc resection and curative resection rates did not differ. Compared with the single group, each procedure time was faster (31.8 ± 23.6 min vs. 45.8 ± 44.8, $P = 0.002$), but total procedure time was significantly longer in the simultaneous group (70.6 ± 33.4 vs. 45.8 ± 44.8 min, $P = 0.01$). Rates of adverse events including bleeding and perforation were not higher in the simultaneous group but the mean blood pressure, incidence of bradycardia and the amount of sedative drug used during ESD were significantly higher in the simultaneous group. Multiple logistic regression analysis identified non-experienced physician, lesion size ≥ 40 mm and submucosal fibrosis as an independent risk factor for procedure duration (≥ 90 min) (Odds ratio 11.852, 18.280, and 3.672; $P < 0.05$, respectively).

Conclusions Simultaneous ESD for multiple synchronous colorectal lesions is safe and feasible compared with single ESD and can reduce the burden to patients, length of hospital stay and medical expense. These results need to be elucidated by further studies.

Introduction

Colorectal cancer is one of the most common causes of cancer-related death worldwide [1], and removal of colorectal adenomas is known to reduce the risk of subsequent colorectal cancer development and colorectal cancer death [2]. Endoscopic submucosal dissection (ESD) for gastrointestinal lesions enables en bloc resection with tumor-free margins and is not limited by the lesion size or location. Colorectal ESD is technically more difficult than gastric or esophageal ESD because of the anatomical features of the colon, such as the thin wall and flexures, which challenge the maneuverability of the scope, increasing the risk of adverse events (AEs) [3]. Although ESD is an organ-sparing procedure with preservation of function of the colon, the risk of synchronous and metachronous colorectal tumors developing at other sites is a major problem. When sequential ESD is selected for treatment of multiple large colorectal lesions, bowel preparation is needed before each of the ESD procedures, which is burdensome to patients. Moreover, separate procedures for each lesion would result in a longer period of hospitalization and increased medical expenses. To the best of our knowledge, there is no consensus on the optimal treatment

protocol for large synchronous colonic lesions that cannot be removed en-bloc with conventional endoscopic mucosal resection (EMR). We have performed simultaneous ESD for multiple synchronous colorectal lesions. This study was aimed at determining the feasibility of simultaneous ESD for multiple synchronous colorectal lesions by evaluating the safety and efficacy of the procedure.

Patients and methods

Patients

Data from 252 consecutive patients who underwent ESD for 280 colorectal lesions at Omori Red Cross Hospital between April 2012 and June 2016 were reviewed in this study. Of the 252 patients, 6 patients with multiple large colorectal lesions treated by sequential ESD were excluded from this study. Of the 246 patients, 23 underwent simultaneous ESD for a total of 51 synchronous colorectal lesions, while the remaining 223 patients underwent ESD for single colorectal neoplasms. We compared data for the 2 groups. ESD was considered to be indicated for tumors that were difficult to resect en bloc with EMR. Japanese guidelines have been published on indications for colorectal ESD [4]. The primary target lesions are large colorectal tumors, such as laterally spreading tumor-granular type (LST-G) or laterally spreading tumor-non-granular type (LST-NG), which are suspected to be intramucosal, or slightly invasive submucosal cancers measuring >20 mm in diameter [5, 6]. Even if tumor diameter is <20 mm, presence of scars due to previous endoscopic treatment or biopsies can also be indications for ESD.

Method of colorectal ESD

All patients were admitted before ESD for bowel preparation with 2 L polyethylene glycol electrolyte solution. Conscious sedation with flunitrazepam and pethidine was used in all cases. Blood pressure, heart rate, electrocardiogram, and oxygen saturation were monitored during the procedure. Intravenous (IV) glucagon or scopolamine was administered to reduce colonic movements. As a rule, prophylactic antibiotics were not administered before the ESD, however, patients with muscle layer injury occurring during the ESD or intraoperative perforation received IV antibiotic treatment (cefazolin sodium hydrate or meropenem hydrate). In addition, analgesics were administered for pain relief only when a patient complained of abdominal pain after ESD. After ESD, the scheduled hospital stay for all patients was 5 days.

Histopathological assessment

All resected specimens were cut into 2-mm slices and stained with hematoxylin and eosin. Specimens were examined to determine histological type, depth of invasion, presence/absence of lymphatic invasion and vascular involvement, and the lateral and vertical resection margins. “En bloc resection” was defined as removal of tumor in a single piece. Patients were defined as having undergone “curative resection” when all of the following criteria based on the Japanese Classification for Cancer of the Colon and Rectum were met: lateral and vertical margins free of tumor, tumor intramucosal carcinoma or carcinoma with slight submucosal invasion (invasion depth < 1000 µm), no lymphatic invasion, vascular involvement, or poorly differentiated component [7].

Strategy for simultaneous ESD

The strategy for simultaneous ESD for multiple large lesions was as follows: (1) time rule: A longer procedure time will increase AEs such as abdominal fullness, pain and perforation [8, 9]. Therefore, when it took more than about 90 minutes, (~double the mean operative time [43.2 min] in all lesions) to treat one of the multiple lesions, we switched from simultaneous ESD to sequential ESD; (2) lesion rule: If one or more of the lesions was >40 mm in diameter (requiring resection of more than half the circumference) or was predicted to have severe fibrosis (it would have a high risk of complications and take more time), we selected sequential ESD.

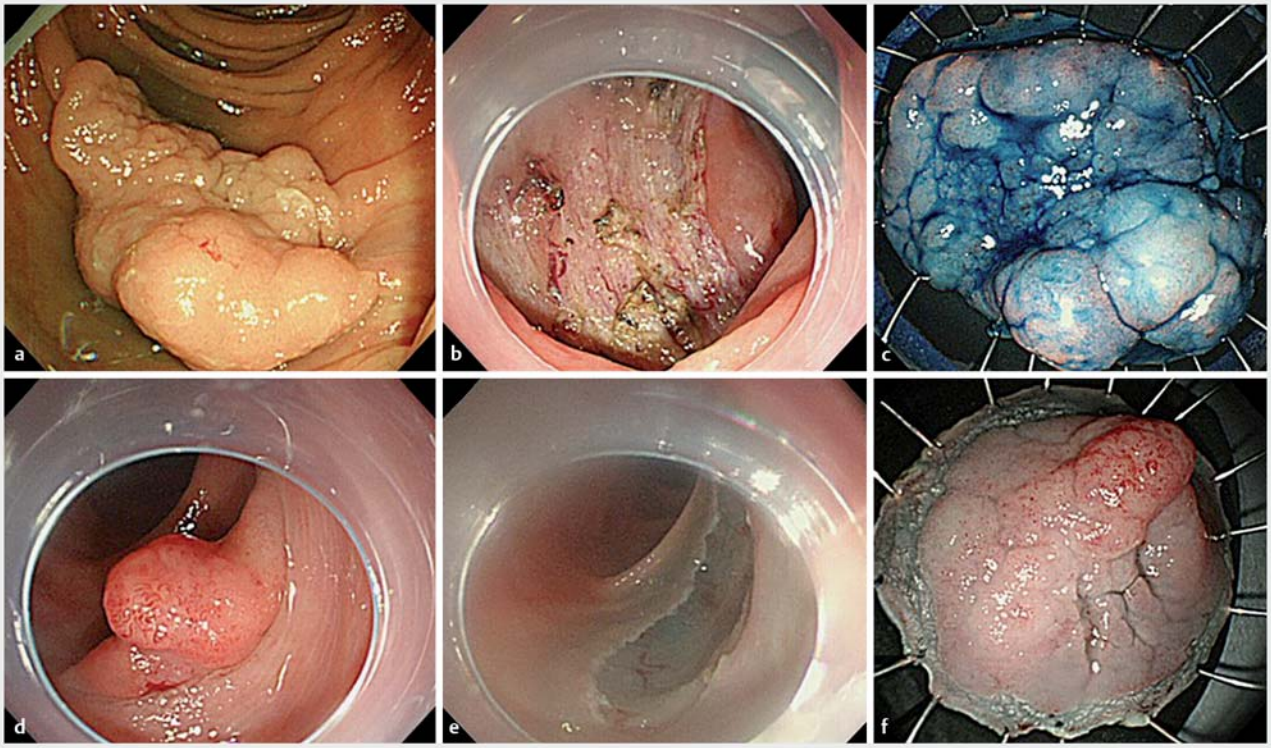
The ESD procedure was performed using a single-channel endoscope (PCF-260AZI, GIF-Q260J; Olympus Co., Tokyo, Japan), with carbon dioxide insufflation. A transparent attachment (D-201-11802; Olympus Co.) was used at the tip of the scope. We used the Flex Knife (KD-630L; Olympus, Tokyo, Japan) or the Dual knife, KD-650L; Olympus, Tokyo, Japan) with a VIO 300 D high-frequency generator (ERBE, Tübingen, Germany) for tumor resection.

Simultaneous ESD was performed for double lesions (▶ **Fig. 1**). The more advanced lesion or more difficult-to-resect lesion (larger lesion, with submucosal fibrosis, or a difficult location) was resected first. If the malignant potential or technical difficulty was almost equal to 2 lesions, the oral side lesion was resected first to prevent damage to the ulcer after the first resection; next the anal lesion was resected. After injection of normal saline solution with a small amount of indigo carmine and epinephrine hydrochloride, 0.4 % sodium hyaluronate was injected into the submucosal layer. After injection, a circumferential incision was made and submucosal dissection was performed using a Flex or Dual knife. In all patients, the procedures were performed by 1 physician (H.C.), who had experience with about 500 ESD cases (including about 200 colorectal ESD cases), and 2 endoscopists who had each performed more than 30 gastric ESD procedures and had not performed colorectal ESD. Perforation during ESD was defined as occurrence of an immediately recognizable hole in the bowel wall. Submucosal fibrosis was classified into 3 grades of severity (F0 – 2) (F0: no fibrosis; F1: mild fibrosis; F2: whitish submucosa or severe fibrosis) [10].

Data and statistical analysis

Detailed information about endoscopic images, procedures and pathological examination results was obtained from the patients’ medical records. Patients and procedures were divided into simultaneous and single ESD groups.

Parameters monitored during ESD, including blood pressure, heart rate and SpO_2, procedure time, dose of sedative drug used, and occurrence of AEs such as postoperative bleeding and perforation were compared between 2 groups. Parameters measured in the postoperative period, such as white



▶ **Fig. 1** Simultaneous ESD for double colorectal cancer. **a** First LST-G-Mix lesion in the ascending colon. **b** Artificial ulcer after the first ESD. **c** Resected specimen of the first lesion. **d** Second LST-NG lesion in the descending colon. **e** Artificial ulcer after the second ESD. **f** Resected specimen of the second lesion.

blood cell count (WBC) and serum c-reactive protein (CRP) on the day after the ESD, need for analgesic use, need for antibiotics, occurrence of delirium, and length of hospital stay after ESD were also compared between the 2 groups.

For statistical analyses, we used the Chi-squared test, Fisher's exact test and the Student's *t* test. We then further confirmed the associations with multiple logistic regression analyses. The odds ratio (OR) and 95 % confidence interval (95 % CI) were calculated for each variable. All the analyses were performed using SPSS 23 for Windows. *P* values < 0.05 were considered to denote statistical significance.

Ethics

The study was conducted in accordance with the principles laid down in the Declaration of Helsinki, and with the approval of the institutional review board of our hospital (No.16 – 9).

Results

Patient and lesion characteristics

A total of 246 patients who had undergone endoscopic resection for 274 colorectal lesions were enrolled in this study. Of the 246 patients, 23 who had 2 or more colorectal lesions underwent simultaneous ESD (simultaneous ESD group), yielding a simultaneous ESD rate for synchronous colorectal neoplasia of 9.3 % (23/246). In the simultaneous ESD group, 1 patient had quadruple lesions, 3 patients had triple lesions, and the remaining 19 patients had double lesions. Baseline characteristics of the patients who underwent colorectal ESD are shown in ▶ **Table 1**. The mean age of the patients in the simultaneous ESD group was higher (73.4 ± 6.6 vs. 68.0 ± 11.7 yr; $P = 0.031$). The number of patients on an antithrombotic drug was higher in the simultaneous ESD group, however, the difference did not reach statistical significance ($P = 0.058$). There were no significant differences in any of the other baseline characteristics between the 2 groups.

As shown in ▶ **Table 2**, lesion location was more often in the right colon and less often in the rectum in the simultaneous ESD group. There were no significant differences in morphologic or histopathologic characteristics of the tumors between the 2 groups. Sample sizes and lesion sizes were significantly smaller in the simultaneous ESD group than in the single ESD group (33.7± 9.4 mm and 24.5 ± 8.2 mm, respectively, in the simultaneous ESD group vs. 37.5 ± 17.4 mm and 29.5 ± 16.7, respectively, in the single ESD group; $P = 0.031$ and 0.002, respectively). As compared to the single ESD group, the procedure time for each lesion was shorter (31.8 ± 23.6 vs. 45.8 ± 44.8 min; $P = 0.002$), and the incidence of submucosal fibrosis encountered during the ESD was lower in the simultaneous ESD group (5 lesions vs. 46 lesions; $P = 0.076$).

▶ **Table 1** Characteristics of patients.

	Single ESD group	Simultaneous ESD group	*P* value
Number of patients, n	223	23	
Sex, male, n (%)	125 (56.1 %)	10 (43.5 %)	0.175
Age, mean ± SD, years	68.0 ± 11.7	73.4 ± 6.6	0.031
Obesity, n (%)	44 (19.7 %)	3 (13.0 %)	0.323
Past history of gastrointestinal cancer, n (%)	36 (16.1 %)	4 (17.4 %)	0.488
Comorbidities, n (%)	49 (22.0 %)	5 (21.8 %)	0.609
Dementia, n (%)	5 (2.2 %)	1 (4.3 %)	0.449
Antithrombotic drug use, n (%)	33 (14.8 %)	7 (30.4 %)	0.058

SD standard deviation
Obesity: BMI (Body Mass Index) ≥ 25 kg/m^2
Comorbidities include cardiovascular diseases, renal diseases, diabetes and liver cirrhosis
Gastrointestinal cancer includes gastric or colon cancer
Antithrombotic drug includes anticoagulant drug and antiplatelet drug

▶ **Table 2** Clinicopathological characteristics of single and simultaneous lesions.

	Single ESD group	Simultaneous ESD group	*P* value
Number of lesions, n	223	51	
Location			0.004
▪ Right colon	114 (51.1 %)	39 (76.5 %)	0.001
▪ Left colon	57 (25.6 %)	7 (13.7 %)	0.097
▪ Rectum	52 (23.3 %)	5 (9.8 %)	0.035
Macroscopic appearance			0.111
▪ protruding (0-I)	14	2	0.06
▪ LST-G	92	14	0.036
▪ LST-NG	117	35	0.02
Sample size, mean ± SD, mm	37.5 ± 17.4	33.7± 9.4	0.031
Lesion size, mean ± SD, mm	29.5 ± 16.7	24.5 ± 8.2	0.002
Procedure time for each lesion, mean ± SD, min	45.8 ± 44.8	31.8 ± 23.6	0.002
Histology			0.297
▪ Adenoma	107	32	
▪ Intramucosal cancer	97	16	
▪ SM slight (< 1000 µm)	11	2	
▪ SM massive (≥ 1000 µm)	8	1	
Physician, experienced, n (%)	156 (70.0 %)	32 (57.1 %)	0.201
Fibrosis			0.162
▪ F0	177	46	0.076
▪ F1	40	5	0.111
▪ F2	6	0	0.287

LST-G, laterally spreading tumor – granular type; LST-NG, laterally spreading tumor – non-granular type; Right colon, cecum, ascending and transverse colon; Left colon, descending and sigmoid colon; F0, no fibrosis; F1, mild fibrosis; F2, severe fibrosis

▶ **Table 3** Comparison of intraoperative parameters.

	Single ESD group	Simultaneous ESD group	*P* value
Number of patients, n	223	23	
Total procedure time, mean ± SD, min	45.8 ± 44.8	70.6 ± 33.4	0.01
Blood pressure before ESD, mean ± SD, mmHg	137.1 ± 22.9	142.7 ± 21.8	0.266
Peak blood pressure during ESD, mean ± SD, mmHg	141.0 ±22.8	155.1 ± 15.1	< 0.01
Bradycardia during ESD, n (%), /min	7 (3.1 %)	5 (21.7 %)	0.002
SpO_2 < 90 %, n (%)	64 (28.7 %)	9 (39.1 %)	0.208
Dose of sedative drug (flunitrazepam) mean ± SD, mg	1.02 ± 0.56	1.31 ± 0.57	0.021

SD, standard deviation; bradycardia, heart rate less than 50 /min

▶ **Table 4** Procedural outcomes.

	Single ESD group	Simultaneous ESD group	*P* value
Number of lesions, n	223	51	
En bloc resection, n (%)	222 (99.6 %)	51	0.814
Curative resection, n (%)	212 (95.1 %)	49 (96.1 %)	0.552
Additional surgery for non-curative resection lesions, n (%)	7 (3.1 %)	1 (2.0 %)	0.549

▶ **Table 5** Clinical outcomes after ESD.

	Single ESD group	Simultaneous ESD group	*P* value
Number of patients, n	223	23	
Delirium after ESD, n (%)	3 (1.3 %)	1 (4.3 %)	0.326
WBC (on the day after the ESD), mean ± SD, /μl	7686 ± 2794	7257 ± 1576	0.469
CRP (on the day after the ESD), mean ± SD, mg/dL	0.9 ± 1.9	1.5 ± 3.0	0.178
Need for analgesic use after ESD, n (%)	7 (3.1 %)	0	0.499
Need for antibiotic treatment after ESD, n (%)	23 (4.3 %)	1 (4.3 %)	0.315
Adverse events, n (%)	2 (0.9 %)	0	0.821
delayed bleeding, n (%)	0	0	–
perforation, n (%)	2 (0.9 %)	0	0.821
Hospital days, mean ± SD	7.1 ± 1.9	7.1 ± 0.8	0.945

SD, standard deviation

Comparison of intraoperative parameters

Total procedure time was significantly longer in the simultaneous ESD group than in the single ESD group (70.6 ± 33.4 vs. 45.8 ± 44.8 min, $P = 0.01$) (▶ **Table 3**). Although there was no significant difference in blood pressure between the 2 groups before each ESD, peak blood pressure and frequency of bradycardia (heart rate < 50 /min) during ESD were higher in the simultaneous ESD group. In addition, dosage of sedative drug (flunitrazepam) was higher during the ESD in the simultaneous ESD group (1.31 ± 0.57 vs. 1.02 ± 0.56 mg, $P = 0.021$).

Comparison of clinical outcomes

Clinical outcomes, including rates of en bloc resection, curative resection and additional surgery for cases of non-curative resection did not differ significantly between the 2 groups (▶ **Table 4**).

▶ **Table 6** Factors associated with prolonged procedure time.

	Univariate, OR (95 % CI)	*P* value	Multivariate, OR (95 % CI)	*P* value
Physician, non-experienced	3.099 (1.382 – 6.948)	0.006	11.852 (3.337 – 42.103)	< 0.01
Age, ≥ 80 years old,	1.142 (0.409 – 3.190)	0.8		
Obesity	1.318 (0.503 – 3.457)	0.574		
Antithrombotic drug use	0.760 (0.251 – 2.304)	0.628		
Lesion diameter ≥ 40 mm,	17.0 (6.929 – 41.706)	< 0.01	18.280 (4.821 – 69.305)	< 0.001
Morphology				
LST-G	1	0.005	1	0.943
LST-NG	1.875 (0.537 – 6.546)	0.324	0.780 (0.146 – 4.180)	0.772
0-I	6.905 (1.768 – 26.963)	0.005	0.898 (0.127 – 6.362)	0.914
Location				
Rectum	1	0.034	1	0.356
Left colon	0.324 (0.132 – 0.796)	0.014	0.439 (0.124 – 1.552)	0.201
Right colon	0.914 (0.304 – 2.746)	0.873	1.131 (0.263 – 4.853)	0.869
Histology				
Adenoma	1	0.002	1	0.115
Intramucosal cancer	9.926 (2.428 – 40.586)	0.001	5.115 (0.902 – 29.025)	0.065
Submucosal cancer	1.552 (0.508 – 4.744)	0.44	1.423 (0.334 – 6.056)	0.633
Fibrosis,	5.107 (2.226 – 11.716)	< 0.01	3.672 (1.142 – 11.803)	0.029
Perforation	9.462 (0.575 – 155.766)	0.116		
Biopsy before ESD	1.478 (0.474 – 4.608)	0.5		

Obesity BMI (Body Mass Index) ≥ 25 kg/m^2; LST-G, laterally spreading tumor – granular type; LST-NG, laterally spreading tumor – non-granular type; Right colon, cecum, ascending and transverse colon; Left colon, descending and sigmoid colon

Total procedure time was longer in the simultaneous ESD group, however, the incidence of AEs such as bleeding and perforation did not differ between the 2 groups. Mean number of hospital days and need for analgesic or antibiotic use were not significantly different between the 2 groups. Also, the increment of the WBC count and serum CRP on the day after ESD were not significantly different between the 2 groups (▶ **Table 5**). Follow-up data were available for all patients. The median follow-up period was 7 months (range 1 – 27 months) in the simultaneous ESD group and 23 months (range 1 – 50 months) in the single ESD group.

Factors increasing risk of a prolonged procedure

Prolonged procedure was defined as a procedure time of 90 min or longer, which was about twice the time of the mean procedure time in the single ESD group (45.8 min). Clinical characteristics and factors in the cases where the procedure was prolonged are shown in ▶ **Table 6**. Univariate and multiple logistic regression analysis identified the following as significant independent factors for a prolonged procedure time: non-experienced physician, lesion diameter ≥ 40 mm, and presence of submucosal fibrosis (OR: 11.852, 18.280, and 3.672; 95 % CI = 3.337 – 42.103, 4.821 – 69.305, and 1.142 – 11.803, respectively; $P < 0.05$ for all).

Discussion

To the best of our knowledge, this study is the first to demonstrate the safety and feasibility of simultaneous colorectal ESD for multiple colorectal lesions as compared to that of ESD for a

single lesion. A previous study evaluated the feasibility of simultaneous gastric ESD for synchronous gastric lesions [11]. However, the safety of colorectal ESD, which needs a higher level of skill and is associated with a higher risk of AE s, cannot be expected to be equivalent to that of gastric ESD.

In this study, comparison of the baseline characteristics showed that mean age in the simultaneous ESD group was higher, however, there were no significant differences in the frequency of comorbidities, past history of gastrointestinal cancer, frequency of obesity or frequency of antithrombotic drug use between the 2 groups. In the simultaneous ESD group, lesions were located more frequently in the right colon (76.5 %) and less frequently in the rectum (9.8 %). In addition, the ratio of laterally spreading tumor-non-granular type (LST-NG) to non-LST-NG was higher in the simultaneous ESD group (68.6 % vs. 52.5 %). The clinicopathological characteristics of multiple LSTs are still unclear, but our results were almost compatible to a previous Japanese report about multiple LSTs in terms of ratio of LST-NG, frequency of lesions in the right-sided colon versus rectum, and incidence of cancer [12].

As expected, total procedure time was longer in the simultaneous ESD group. However, there were no significant differences in intraoperative parameters, clinical courses or frequency of AEs such as bleeding and perforation between the 2 groups. Also, there were no significant differences in the rates of en bloc resection or curative resection between the 2 groups. In addition, neither was the hospitalization time longer, nor was the need for analgesic use higher in the simultaneous ESD group as compared to the single ESD group. Our findings demonstrate that the technical safety and feasibility of simultaneous ESD for multiple colorectal lesions are as acceptable as those of ESD for a single neoplasm. Therefore, simultaneous ESD appears feasible and its adoption, that is, simultaneous resection of 2 or more lesions on the same day, can reduce: 1) the burden of the patients by reducing the need for repeated bowel preparation; 2) the hospital stay; and 3) the medical expenses.

On the other hand, longer procedure time will increase the amount of air, causing greater paradoxical movement of the endoscope. Kim et al. contended that operator fatigue caused by long procedure time might have been one of the reasons for the high perforation rate in their study [8]. Yoshida et al. described that ESD might be indicated only when the operative time was expected to be less than 2.5 hours because restlessness due to abdominal fullness and pain occurred frequently when the operative time exceeded 2.5 hours [9]. In our study, peak blood pressure and frequency of bradycardia (heart rate < 50 /min) during the ESD were higher in the simultaneous ESD group. However, none of these events posed a clinical problem. The possible causes for these findings may include the higher dose of the sedative drug or abdominal fullness because of the prolonged procedure time. Our analysis revealed 3 significant risk factors for prolonged procedure time (≥ 90 min for 1 colorectal ESD): (1) non-experienced physician; (2) lesion diameter ≥ 40 mm; and (3) presence of submucosal fibrosis.

Performance of ESD by a non-experienced physician was identified as a significant predictor of a prolonged operative time. Risk of perforation during colorectal ESD has been shown to vary depending on lesion diameter and operator experience [13]. The learning curve or the importance of thorough training in colorectal ESD has been evaluated in several Japanese studies [14 – 17]. In this study, an equal number of simultaneous ESDs were performed by non-experienced and experienced physicians (42.9 % vs. 57.1 %), and the ratio of experts to non-experts in the simultaneous ESD group did not differ. At our hospital, colorectal ESDs performed by non-experienced physicians are always supervised by 1 experienced physician. Before each colorectal ESD, the expert decides the operator, considering the size and location of the lesions and the presence/absence of fibrosis. As a result, the overall rate of AEs, including the rate of postoperative bleeding (0 %) and perforation (2/274: 0.7 %) was very low. Thus, our results show the feasibility of simultaneous ESD even when it is performed by well-trained novice physicians, but under the supervision of experts.

Larger lesions also increased the risk of a prolonged procedure. A previous study showed that larger tumor size was an independent factor contributing to risk of perforation [18]. Ohata et al. compared cases with tumors larger and smaller than 50 mm, and demonstrated that colorectal ESD is relatively safe and effective even for large colorectal tumors [19]. Although there were no cases with any AEs, it tended to take more time to resect the 44 lesions that were more than 40 mm in diameter (median time 64 min; range: 12 – 248 min) in this study. These results suggest that close attention should be paid, including to time control, during ESD for large lesions, to avoid AEs.

Colorectal ESD for lesions with fibrosis, especially severe fibrosis, needs a higher level of skill [20]. Matsumoto et al. showed that severe fibrosis was associated with a much longer procedure time and higher risk of perforation [8]. Therefore, accurate prediction of presence/severity of fibrosis before colorectal ESD is very important. Lee et al. reported that presence of submucosal invasion and large tumor diameter (≥ 30 mm) were independent predictors of F2 fibrosis [21]. Makino et al. showed that endoscopic ultrasound (EUS) could be useful to predict the degree of submucosal fibrosis in colorectal lesions before colorectal ESD [22]. These results indicate the importance of more accurate diagnostic endoscopic workup, including magnified endoscopy or EUS, before colorectal ESD. If the lesion is predicted to show severe fibrosis, sequential ESD for multiple lesions may be preferable.

The main limitation of this study was that it was a retrospective single-center study. Therefore, selection bias for the physicians or lesions is inevitable. Based on the experience of the expert, the cases assigned to novice physicians were selected according to the physicians' skill level. In addition, there were 6 cases of multiple large colorectal lesions that were treated with sequential ESD (data not shown). Prospective studies with a larger number of patients will be needed to confirm our results.

Conclusion

In conclusion, simultaneous ESD of multiple colorectal lesions is safe and feasible and may reduce: 1) patient burden; 2) length of hospital stay; and 3) medical expenses. Large lesions (≥ 40

mm in diameter), presence of submucosal fibrosis, and performance of ESD by a non-experienced physician were identified as significant independent risk factors for prolonged procedure time. If prolonged procedure time is predicted, sequential ESD on separate days for multiple colorectal lesions is the preferred treatment option for avoiding AEs.

Competing interests

None

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