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Colorectal endoscopic submucosal dissection using the water pressure method for diverticulum-associated lesions: A case series study (with video)

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ABSTRACT

Background and study aims Colorectal endoscopic submucosal dissection (ESD) of diverticulum-associated lesions is challenging because these lesions require precise excision in narrow spaces. The water pressure method (WPM) uses active water pressure by the waterjet function under saline solution-filled conditions. This study aimed to determine the feasibility of WPM for resection of diverticulum-associated lesions.

Patients and methods This was a retrospective, observational case series study. We reviewed diverticulum-associated lesions treated by ESD with WPM at our institution between June 2017 and July 2021. Diverticulum-associated lesions were classified as follows: type 1, lesions in contact with or within 3 mm of the edge of a diverticulum; type 2, lesions that partially infiltrated the interior of a diverticulum; and type 3, lesions that infiltrated the interior of and completely covered the diverticulum. We collected data on the clinical characteristics and outcomes of the lesions.

Results Seven diverticulum-associated lesions were treated with ESD using WPM. The median lesion size was 37 mm (interquartile range: 25–54 mm). There were three cases of type 1, three cases of type 2, and one case of type 3. Three lesions were resected circumventing the diverticulum, and four lesions involved resection of the diverticulum. The en bloc resection and R0 resection rates were 86 %. One patient had severe fibrosis, which caused perforation, and in another patient, the diverticulum was too deep and narrow to be completely isolated.

Conclusions WPM allowed for precise procedures in the diverticulum. The feasibility of WPM has been suggested for diverticulum-associated lesions, although cases have been complex.

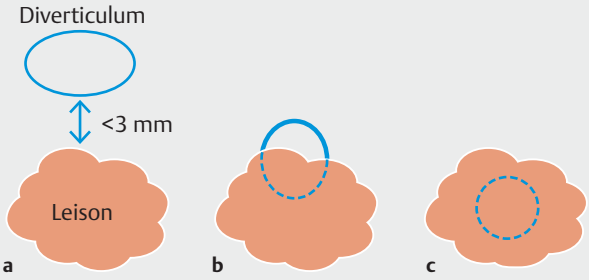
Introduction

Endoscopic submucosal dissection (ESD) has been increasingly performed in early

colorectal neoplasms. Colorectal ESD allows en bloc resection regardless of tumor size [1]. However, some situations make this procedure technically challenging, including diverticulum-associated lesions. A colonic diverticulum is a mucosal and submucosal herniation in the muscle layer through the colonic wall, which indicates an absence of the muscle layer [2]. Therefore, ESD of diverticulum-associated lesions requires pre-

cise procedures in narrow spaces, which have a high risk of perforation.

Conversely, various techniques for successful ESD have been reported, including the water pressure method (WPM) [3]. This method creates an immersion saline solution in the lumen and uses active water pressure. This utilizes buoyancy to produce a traction effect and creates a magnified view owing to the difference in the photorefraction between water and air [4]. In addition, active water pressure not only helps reach beneath the lesion but also enables submucosal dissection in the margins and narrow spaces [5, 6]. Thus, we hypothesized that WPM might be effective for diverticulum-associated lesions. This study aimed to determine the feasibility of WPM for diverticulum-associated.



▶ **Fig. 1** Diverticulum classification. **a** Type 1: lesions in contact with or within 3 mm of the diverticulum edge. **b** Type 2, lesions that partially infiltrate the interior of a diverticulum. **c** Type 3, lesions that infiltrate the interior of and completely cover the diverticulum.

Patients and methods

Study design and eligibility criteria

This retrospective observational study was conducted at a tertiary care hospital. We have used the WPM during ESD since June 2017 [3]. Hence, we reviewed diverticulum-associated lesions treated by ESD with WPM at our institute between June 2017 and July 2021. Eligible cases were identified from a prospectively maintained database in our department. This study was performed in accordance with the 2008 revision of the Declaration of Helsinki, and the protocol was approved by our hospital's institutional review board (20190139). With regard to patient consent, this was a retrospective observational study that does not contain identifiable personal information. Therefore, we publicized the study information on the website and excluded patients who chose to opt-out of the study.

Diverticulum classification

Diverticulum-associated lesions were classified as follows: type 1, lesions in contact with or within 3 mm of the edge of a diverticulum; type 2, lesions that partially infiltrate the interior of a diverticulum; and type 3, lesions that infiltrate the interior of and completely cover the diverticulum (▶ **Fig. 1**) [7, 8].

Preoperative evaluation and indications for ESD

All lesions were evaluated using magnifying endoscopy before resection. The indications for ESD are lesions with endoscopic features suspicious for adenocarcinoma, limited to the mucosa or shallow submucosa, and which are difficult to resect en bloc by snare forceps due to their large size, fibrosis, and so on. If a diverticulum was detected, the degree of involvement was evaluated in detail using a transparent hood, and the feasibility of en bloc resection was carefully discussed. We also fully explained to the patients that the risk of perforation was higher than usual and that the procedure would be performed with surgical backup.

Device and equipment for ESD

ESD was performed using a therapeutic endoscope with a waterjet function (GIF-Q260J, GIF-H290T, GIF-2TQM, PCF-Q260JI, or PCF-H290TI; Olympus Medical Systems, Tokyo, Japan) and carbon dioxide insufflation. A transparent hood (D-201-11804, D-201-13404; Olympus Medical Systems, Tokyo, Japan), short-type small-caliber tip transparent hood, or small-caliber tip transparent hood (DH-28GR, DH-33GR; Fujifilm, Tokyo, Japan) were used. We performed a mucosal incision or submucosal dissection using a 1.5-mm DualKnife J (Olympus Medical Systems, Tokyo, Japan). Minor bleeding was controlled by placing the device's tip into the outer sheath, but hemostatic forceps (Coagrasper, Olympus Medical Systems, Tokyo, Japan) were also used. A submucosal injection of 10 % glycerin solution (Glyceol; Chugai Pharmaceutical Co., Ltd., Tokyo, Japan) containing a small amount of indigo carmine and epinephrine (1:400,000 dilution) was given. In complex cases, 0.4 % sodium hyaluronate (Mucoup, Boston Scientific Japan, Tokyo, Japan) was used. We used the VIO 300 D (ERBE Elektromedizin, Tübingen, Germany) with a dry cut (effect 2.2) for mucosal incisions, swift coagulation (effect 3.5) for submucosal dissection, spray coagulation (effect 1.2) for hemostasis using the tip of the knife, and soft coagulation (effect 6.0) for hemostasis using the coagrasper.

Water pressure method

Basically, WPM was performed according to the following procedure. First, the lumen was thoroughly washed and suctioned. Second, all air in the working space was aspirated, and the lumen was filled with normal saline through a waterjet. Third, initial mucosal incision and trimming of the oral side were performed to create an endpoint of submucosal dissection. Fourth, a full circumferential incision was performed. Fifth, a mucosal flap was made by dissection of the submucosa of the anal side with the application of active water pressure from the waterjet function to widen the submucosal layer. Sixth, dissection of both lateral edges of the submucosa was performed. Finally, submucosal dissection of the central area was performed. WPM is sometimes used in combination with carbon dioxide insufflation. The decision to use WPM was made by each endoscopist.

Treatment strategy for lesions adjacent to or involving diverticulum

We first attempted resection of type 1 or 2 lesions circumventing the diverticulum. For these lesions, sufficient solution was injected into the submucosa between the diverticulum and the lesion to maintain a secure horizontal margin. If the diverticulum could not be circumvented because it was too close to the lesion or for type 3 lesions, resection included the diverticulum. This resection was performed by adequately dissecting the submucosa, except for the diverticulum, and then carefully removing the diverticulum.

Histological evaluation

Resected specimens were pinned onto a plate. The specimens were fixed in formalin, serially sectioned into 2-mm slices and stained with hematoxylin and eosin. Pathological diagnoses were made using the World Health Organization and the Japanese Society for Cancer of the Colon and Rectum criteria [9, 10].

Measured outcomes

From medical records, we collected data on the following clinical characteristics: age, sex, location, lesion size, macroscopic lesion type, and diverticulum classification. We also collected data on the following treatment outcomes: resection procedure (whether the resection circumvents the diverticulum or involves the diverticulum), resection time, en bloc resection, R0 resection, the degree of submucosal fibrosis (F0 = no fibrosis, F1 = mild fibrosis, F2 = whitish submucosa or severe fibrosis), intraoperative perforation, complete closure after resection, delayed perforation, delayed bleeding, post-endoscopic submucosal dissection coagulation syndrome (PECS), and the pathological diagnosis [11]. Resection time was defined as the time from initiation of the submucosal injection to completion of lesion removal. En bloc resection was defined as resection of a lesion in one piece. R0 resection was defined as absence of tumor cells at the margins. Intraoperative perforation was defined as perforation observed during ESD, and delayed perforation was defined as any subsequent perforation. Delayed bleeding was defined as melena or hematemesis that required endoscopic hemostasis after ESD. PECS was defined as any of the following findings on Days 1 to 7 after ESD: obvious abdominal pain, body temperature ≥ 37.5 °C, and white blood cell count ≥ 10,000/μL without extra-luminal air [12].

Results

Clinical characteristics

Among the 454 colorectal lesions treated with ESD at our institution between June 2017 and July 2021, 245 lesions (54 %) were treated using WPM. The proportion of using WPM in the first year of the study period was 8.5 %, 29 % in the second year, 74 % in the third year, and 90 % in the fourth year. There were seven diverticulum-associated lesions (1.5 %). All diverticulum-associated lesions were resected using the WPM during the whole process (There were no diverticulum-associated lesions treated with the conventional method). In all cases, mechanical traction devices were not used. Clinical characteristics of lesions are shown in ▶ **Table 1**. The median age of patients was 70 years (IQR, 65–78 years), and five patients were men. The lesions in three cases were in the cecum and four were in the ascending colon. Median lesion size was 37 mm (IQR: 25–54 mm). All cases were flat elevated lesions, and there were three cases of type 1, three cases of type 2, and one case of type 3 diverticulum-associated lesions.

▶ **Table 1** Clinical characteristics of diverticulum-associated lesions treated using the water pressure method (N = 7)

Age, years	Median [IQR]	70 [65–78]
Sex	Male, N (%)	5 (71)
Location	Cecum, N (%) Ascending, N (%)	3 (43) 4 (57)
Lesion size, mm	Median [IQR]	37 [25–54]
Macroscopic type	Flat elevated, N (%)	7 (100)
Diverticulum classification	Type 1, N (%)	3 (43)
	Type 2, N (%)	3 (43)
	Type 3, N (%)	1 (14)

IQR, interquartile range.

Treatment outcomes

Outcomes of diverticulum-associated lesions treated with WPM are presented in ▶ **Table 2**. Three lesions were resected circumventing the diverticulum (two type 1 and one type 2), and four lesions were resected with the diverticulum (one type 1, two type 2 and one type 3) (▶ **Fig. 2**). Six cases (86 %) underwent en bloc and R0 resections. Three patients had mild fibrosis of the F1 in non-diverticular areas. One patient had severe fibrosis of the F2 in the diverticular area. Intraoperative perforation, delayed bleeding, and PECS occurred in one patient each. Delayed perforation did not occur in any of these patients. Four cases were histologically adenocarcinomas, one was an adenoma, and two were sessile serrated lesions. Detailed clinical characteristics and treatment outcomes for each case are presented in ▶ **Table 3**.

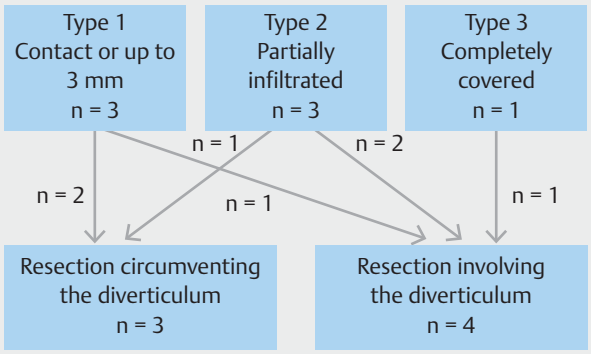
Case presentations

Case No. 1, Resection involving diverticulum (▶ Fig. 3) (▶ Video 1) A flat, elevated, 54-mm lesion was found in the cecum, and the diverticulum was classified as type 2 (partially infiltrated the diverticulum) (▶ **Fig. 3a**, ▶ **Fig. 3b**). In ESD, first, mucosal incision and submucosal dissection were performed, except for in the diverticulum (▶ **Fig. 3c**). Next, the process was moved to dissection of the diverticulum area. A magnified view was obtained by filling the lumen with saline solution. Then, water pressure was applied from the waterjet to widen the submucosa (WPM), and precise dissection was performed with direct visualization of the submucosa, even in a diverticulum with a narrow working space (▶ **Fig. 3d**). In addition, elimi-

▶ **Table 2** Treatment outcomes of diverticulum-associated lesions treated using the water pressure method (N = 7).

Resection procedure	Resection circumventing the diverticulum, N (%)	3 (43)
	Resection involving the diverticulum, N (%)	4 (57)
Resection time, min	Median [IQR]	78 [72–89]
En bloc resection	yes, N (%)	6 (86)
R0 resection	yes, N (%)	6 (86)
Fibrosis	F0, N (%)	3 (43)
	F1, N (%)	3 (43)
	F2, N (%)	1 (14)
Intraoperative perforation	yes, N (%)	1 (14)
Delayed perforation	yes, N (%)	0 (0)
Delayed bleeding	yes, N (%)	1 (14)
PECS	yes, N (%)	1 (14)
Pathological diagnosis	Adenocarcinoma, N (%)	4 (58)
	adenoma, N (%)	1 (14)
	SSL, N (%)	2 (28)

IQR, interquartile range; PECS, post-endoscopic submucosal dissection coagulation syndrome; SSL, sessile serrated lesion.



▶ **Fig. 2** Outcomes of the diverticulum classification and the resection procedure.

nation of the effect of gravity by utilizing buoyancy provided reasonable counteraction, making it easier to dissect. Finally, en bloc resection involving the diverticulum was performed without adverse events (AEs) (▶ **Fig. 3e**, ▶ **Fig. 3f**). The pathological diagnosis was adenocarcinoma, which necessitated R0 resection.

Case No. 2, Resection circumventing diverticulum (Type 1) (▶ Fig. 4) A flat, elevated, 35-mm lesion was found in the ascending colon, with a type 1 diverticulum (adjacent to the diverticulum) (▶ **Fig. 4a**, ▶ **Fig. 4b**). In ESD, we started with a mucosal incision in the area adjacent to the diverticulum to separate it from the lesion. However, this area was very narrow, and bleeding caused by the submucosal injection interfered with the procedure. As a result, visibility was very poor, and conventional ESD was difficult to perform (▶ **Fig. 4c**). To overcome this problem, we decided to use WPM. Using active water pressure by waterjet function in saline solution-filled conditions, the view was magnified more sterically, blood was blown away, and precise mucosal incisions were made successfully (▶ **Fig. 4d**, ▶ **Fig. 4e**). For the subsequent process, we dissected the submucosa with a very good field of view using the WPM (▶ **Fig. 4f**). Finally, en bloc resection was performed without any AEs. The pathological diagnosis was sessile serrated lesion, resulting in a R0 resection.

Case No. 4: Resection circumventing diverticulum (Type 2) (▶ Fig. 5) A flat, elevated, 60-mm lesion was found in the ascending colon, with a type 2 diverticulum (partially infiltrated the diverticulum) on the oral side (▶ **Fig. 5a**, ▶ **Fig. 5b**). In ESD, first, mucosal incision and submucosal dissection were performed, except for in the diverticulum of the oral side. The saline solution-filled conditions prevented hyperextension of the colonic wall and allowed even insert of the submucosal injection around the diverticulum, which resulted in a secure horizontal margin between the lesion and diverticulum (▶ **Fig. 5c**, ▶ **Fig. 5d**). We successfully performed resection, circumventing the diverticulum with water pressure (▶ **Fig. 5e**, ▶ **Fig. 5f**). Finally, en bloc resection was achieved without any AEs. The pathological diagnosis was adenocarcinoma, resulting in a R0 resection.

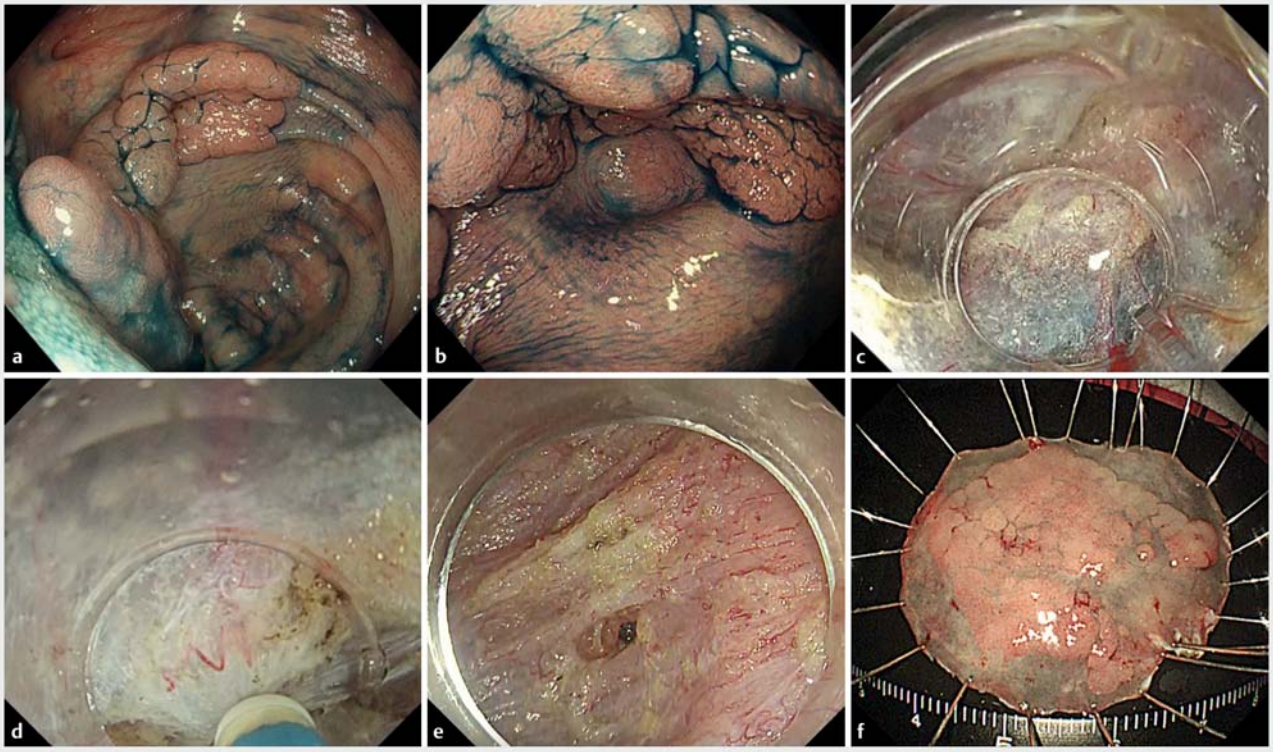
Case No. 5: Complete resection could not be achieved (▶ Fig. 6) A flat, elevated, 37-mm lesion was found in the cecum, with a type 3 diverticulum (thorough infiltration of the diverticulum) (▶ **Fig. 6a**). In ESD, there was a diverticulum in the center of the lesion, which was carefully dissected using WPM (▶ **Fig. 6b**). However, the working space in the diverticulum was extremely small, making it impossible to dissect this area (▶ **Fig. 6c**, ▶ **Fig. 6d**) completely. The pathological diagnosis was adenocarcinoma, and surgical resection was performed to achieve complete resection.

Case No. 6: Intraoperative perforation due to severe fibrosis (▶ Fig. 7) A flat, elevated, 16-mm lesion was found in the cecum, with a type 2 diverticulum (partial infiltration of the diverticulum) (▶ **Fig. 7a**, ▶ **Fig. 7b**). During ESD, severe fibrosis of F2 was present in the diverticulum (▶ **Fig. 7c**). Although dissection with WPM was carefully performed, some submucosa remained due to fibrosis, and intraoperative perforation occurred (▶ **Fig. 7d**). Subsequently, en bloc resection was completed immediately and the wound was completely closed using endoscopic clips (▶ **Fig. 7e**, ▶ **Fig. 7f**). The pathological diagnosis was adenoma, which necessitated R0 resection. Although the patient presented with localized peritonitis postoperatively, the condition resolved with conservative treatment. The patient was discharged on postoperative Day 7.

▶ **Table 3** Detailed clinical characteristics and treatment outcomes for each case (N = 7).

Age	Sex	Location	Size, mm	Macroscopic type	Diverticulum classification	Scope (Hood)	Resection procedure	Resection time, min	En bloc resection	R0 resection	Fibrosis	No.	Intraoperative perforation	Closure	Delayed perforation	Delayed bleeding	PECS	Pathological diagnosis
65	M	Cecum	54	Flat elevated	Type 2	PCF-H290TI (Transparent hood)	Involving the diverticulum	78	+	+	F0	1	–	Complete	–	–	–	Adenocarcinoma
78	M	Ascending	35	Flat elevated	Type 1	PCF-Q260JI (Transparent hood)	Circumventing the diverticulum	72	+	+	F1	2	–	–	–	+	–	SSL
75	F	Ascending	37	Flat elevated	Type 1	PCF-Q260JI (Transparent hood)	Involving the diverticulum	77	+	+	F1	3	–	Complete	–	–	+	Adenocarcinoma
70	F	Ascending	60	Flat elevated	Type 2	PCF-H290TI (ST hood)	Circumventing the diverticulum	143	+	+	F1	4	–	Complete	–	–	–	Adenocarcinoma
89	M	Cecum	37	Flat elevated	Type 3	PCF-H290TI (ST hood)	Involving the diverticulum	89	–	–	F0	5	–	–	–	–	–	Adenocarcinoma
60	M	Cecum	16	Flat elevated	Type 2	PCF-H290TI (Short ST hood)	Involving the diverticulum	46	+	+	F2	6	+	Complete	–	–	–	Adenoma
66	M	Ascending	25	Flat elevated	Type 1	PCF-H290TI (Short ST hood)	Circumventing the diverticulum	78	+	+	F0	7	–	–	–	–	–	SSL

ST hood, small-caliber tip transparent hood; PECS, post-endoscopic submucosal dissection coagulation syndrome; SSL, sessile serrated lesion; M, male; F, female



▶ **Fig. 3** Case no. 1: Resection involving the diverticulum. **a** A flat, elevated lesion 54 mm in size was in the cecum. **b** The diverticulum classification was type 2. **c** In ESD, mucosal incision and submucosal dissection were performed except for the diverticulum. **d** Dissection of diverticulum. The WPM technique allows precise dissection with direct visualization of the submucosa, even in a narrow working space diverticulum. **e** Diverticulum in the wound. Successful resection involving the diverticulum. **f** Resected specimen. ESD, endoscopic submucosal dissection; WPM, water pressure method.

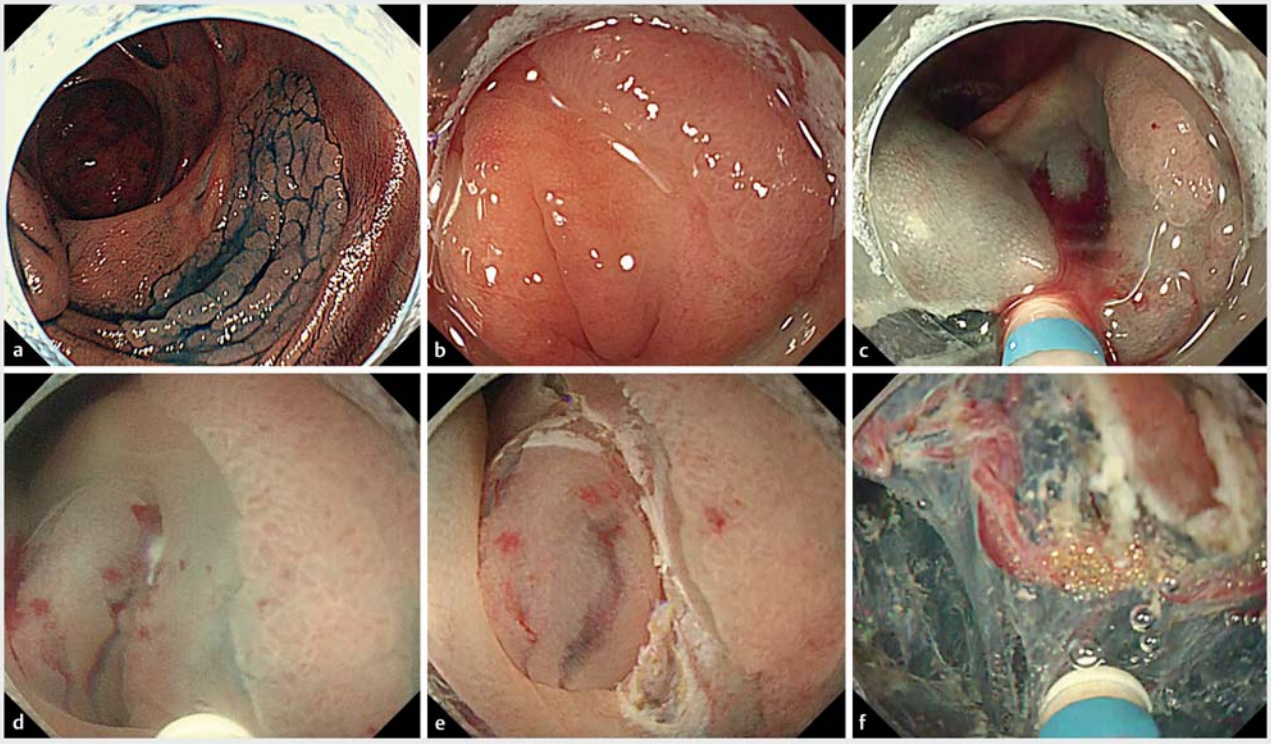
VIDEO

▶ **Video 1** Case no. 1: Resection involving the diverticulum with the water pressure method.

Discussion

In this retrospective case series, we analyzed clinical outcomes of patients with diverticulum-associated lesions treated with ESD using the WPM. As a result, the en bloc and R0 resection rates were both 86 %. WPM allowed for precise excision within the diverticulum. The feasibility of WPM for diverticulum-associated lesions was suggested. To the best of our knowledge, this is the first case series to summarize colorectal ESD using WPM for diverticulum-associated lesions.

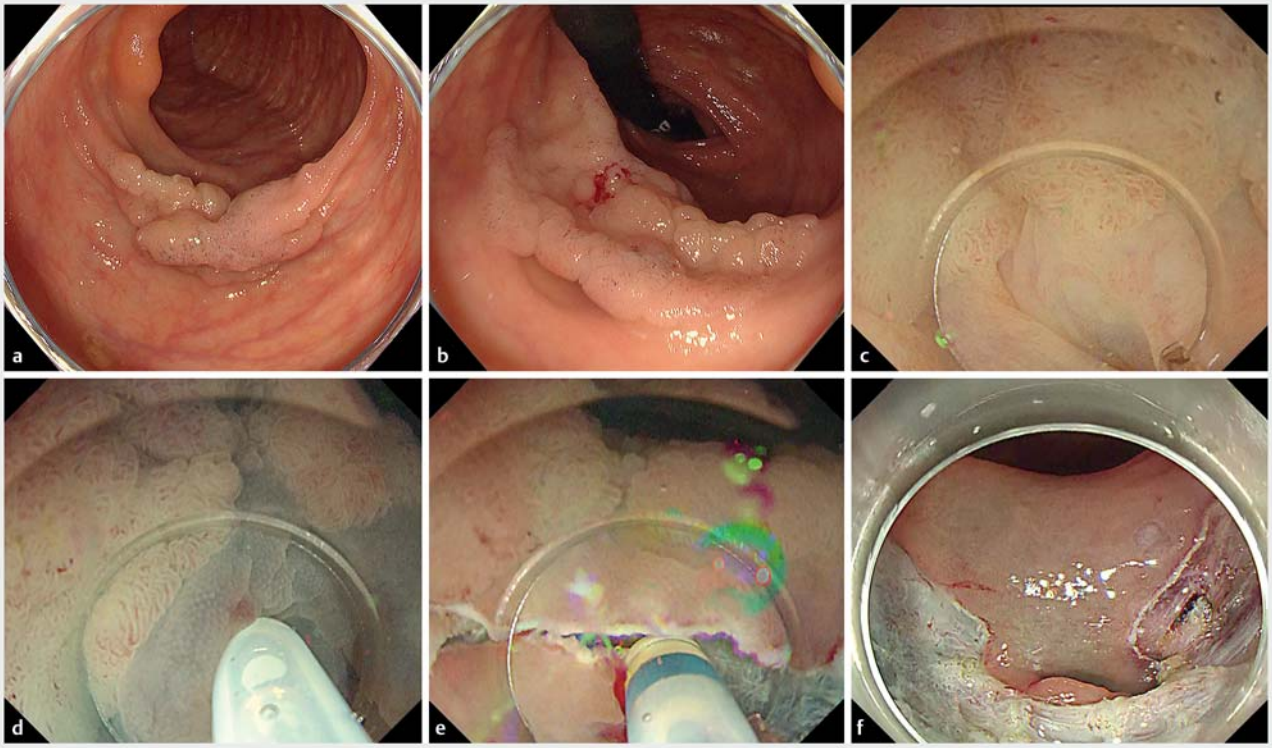
The prevalence of colonic diverticula has been increasing in recent years, and the frequency of diverticulum-associated lesions is also expected to increase [13, 14]. Minimally invasive endoscopic treatment is usually the first choice of treatment for colorectal tumors [1]. However, the indications for endoscopic resection of diverticulum-associated lesions remain controversial. The diverticulum is three-dimensional, which makes en bloc resection with a snare difficult. In addition, the risk of perforation is high even with snare resection because of the absence of proper muscular layers [15]. It is also difficult to standardize conventional colorectal ESD, which has a high rate of en bloc resection regardless of tumor size, because of the technical difficulty and increased risk of perforation in the diverticulum area. One report showed that the en bloc resection rate for colorectal ESD involving a diverticulum was 33 % [7]. Several reports have shown the feasibility of endoscopic full-thickness resection (EFTR) using a full-thickness resection device or endoscopic band ligation; however, EFTR is limited by lesion size, allowing for en bloc resection [16–23]. It is necessary to establish an endoscopic treatment method that enables en bloc resection of diverticulum-associated lesions, regardless of size.



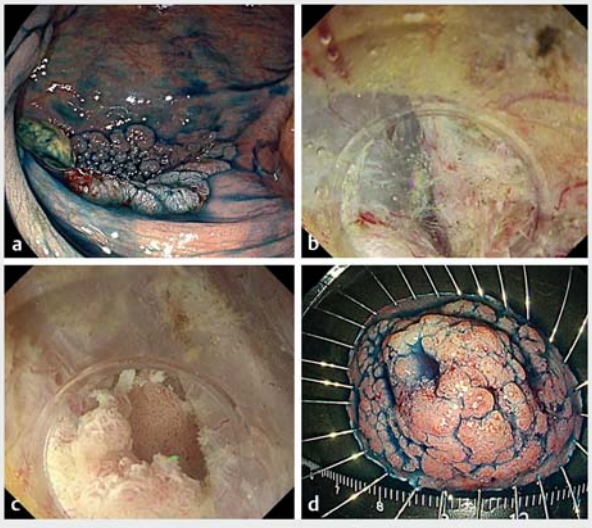
▶ **Fig. 4** Case no. 2: resection circumventing the diverticulum (Type 1). **a** Flat, elevated 35-mm lesion in the ascending colon. **b** The diverticulum classification was type 1. c The area adjacent to the diverticulum was very narrow, and bleeding caused by the submucosal injection interfered with the procedure. **d** WPM facilitated a magnified view and blew away the blood. **e** Precise mucosal incisions were successfully made. **f** WPM facilitated submucosal dissection with a good view. WPM, water pressure method.

Recently, several ESD techniques have been reported to overcome diverticulum-associated lesions. One of them is mechanical traction. With it, a thread or band is fixed to the lesion and pulled to obtain good countertraction and a clear field of vision. Once traction is good, the submucosal layer can be dissected safely and efficiently, even in the diverticulum area [8, 24–29]. However, this method also has several limitations. In some cases, it is difficult to judge when and where to apply a traction device, and making this judgment requires some experience. It also takes time to correct, once mechanical traction is applied in an improper direction. In addition, it is difficult to achieve good traction in some cases because luminal flexion is too strong or the working space is too narrow, which is strongly dependent on the aspect of the lesion. It is difficult to overcome these situations using only the skill of an endoscopist.

The WPM was developed to overcome technical challenges of duodenal ESD [3]. There are several remarkable advantages of ESD with WPM. First, ESD with WPM creates buoyancy and natural traction toward the center of the lumen regardless of the direction of gravity. This natural traction effect can be easily and reversibly created. Second, a magnified view can be obtained, owing to the difference in photorefraction between water and air [4]. Third, the WPM does not require carbon dioxide insufflation to create the field of view. Excessive carbon dioxide insufflation can cause hyperextension of the intestinal tract, which stretches the muscle layer and may increase risk of perforation. This situation can also lead to changes in the shape of the entire intestinal tract and poor scope maneuverability. The WPM can prevent hyperextension, decrease risk of perforation, and maintain good scope maneuverability. In addition, preventing hyperextension may facilitate even insertion of submucosal injection even around the diverticulum, which makes the procedure that much easier to perform. Fourth, active water pressure can create water flow to widen the submucosa. During the initial dissection phase of colorectal ESD, before insertion under the mucosal flap, the submucosal layer was not sufficiently visible, making the procedure difficult. However, active water pressure opens the submucosa and improves visibility, making it easier to penetrate the submucosa. When working in a narrow space, the water pressure also helps widen the space, allowing safe and precise dissection of the submucosa [3, 5, 6]. The above advantages of WPM, such as natural traction effect, magnification effect, prevention of intestinal hyperextension, and the ability to widen the submucosa by water pressure even in narrow spaces, are not available with mechanical traction devices and may help in treatment of diverticulum-associated lesions, as in the cases in this study. In addition, WPM is usable at any point during the procedure and in any lesion location without special devices and can complement other useful methods, such as mechanical traction and pocket



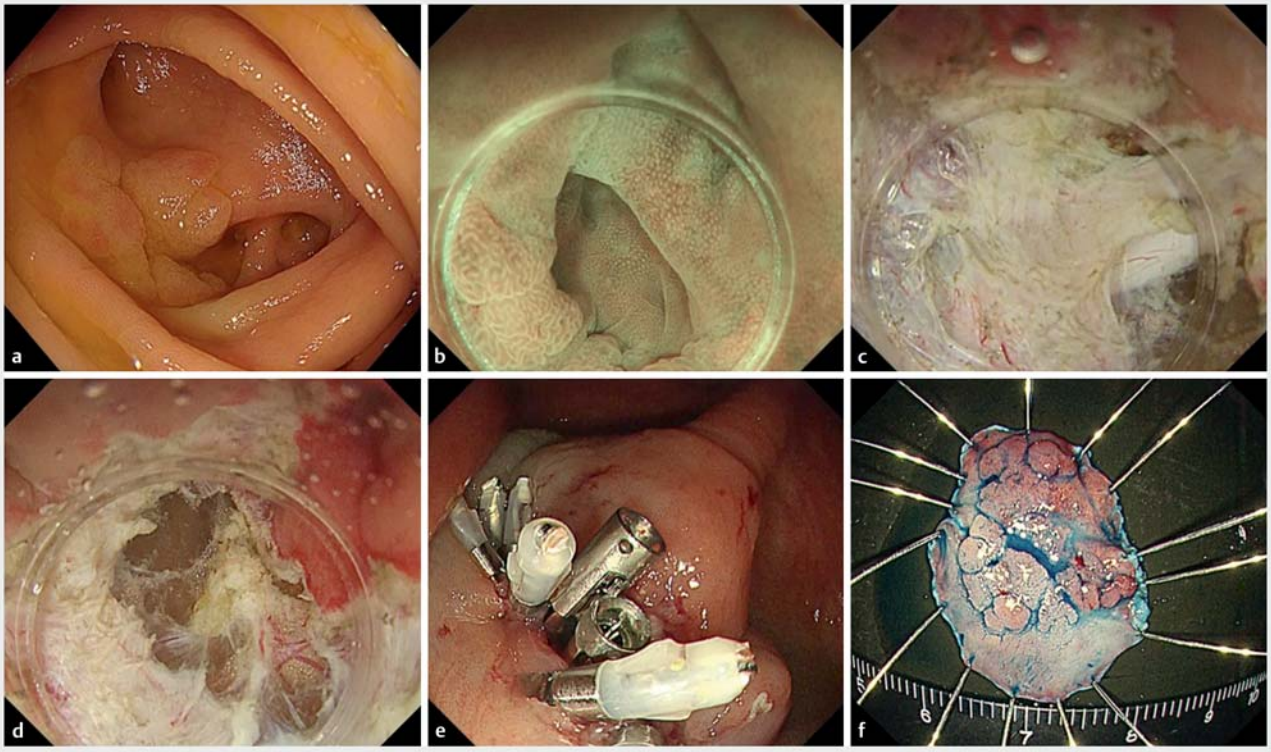
▶ **Fig. 5** Case no. 4: Resection circumventing the diverticulum (Type 2). **a** Flat, elevated 60-mm lesion in the ascending colon (forward-view). **b** The diverticulum was located on the oral side of the lesion, in which classification was type 2 (retroflexed-view). **c** The saline solution-filled conditions prevented hyperextension of the colonic wall (retroflexed-view). **d** The submucosal injection got a secure horizontal margin between the lesion and the diverticulum (retroflexed-view). **e** Precise mucosal incision around the diverticulum was made (retroflexed-view). **f** Resection circumventing the diverticulum was achieved (forward-view). WPM, water pressure method.



▶ **Fig. 6** Case no. 5: Complete resection could not be achieved. **a** Flat, elevated 37-mm lesion in the cecum. **b** There was a diverticulum in the center of the lesion (type 3), which was carefully dissected using WPM. **c** The working space in the diverticulum was extremely small, making it impossible to completely dissect this area. **d** The resected specimen. WPM, water pressure method.

creation, which may improve the outcome with diverticulum-related lesions even more [30, 31].

However, WPM may also have some disadvantages. WPM is associated with a potential risk of abdominal pollution due to leakage of intestinal contents and tumor cells into the abdominal cavity in cases of perforation. However, this risk can be minimized by adequately cleaning the intestinal tract prior to treatment. Nevertheless, there are some cases in which hard stools inserted into the diverticulum cannot be completely removed. In addition, there some cases are too complex to safely and completely resect even when using the WPM. In case no. 6, not only a diverticulum but also other factors challenged treatment, such as severe fibrosis, which caused perforation. This patient's intestinal tract was thoroughly washed before the procedure, and we performed complete closure after resection, resulting in discharge from the hospital without major problems on the seventh postoperative day. In case 5, the diverticulum was too deep and narrow to be completely isolated. Although indications for endoscopic treatment of diverticulum-associated lesions are unclear, this case series shows that treatment methods for lesions with very deep and narrow diverticula or predicted severe fibrosis should be chosen carefully. For these types of lesions, the first consideration is whether endoscopic resection is possible, and depending on the situation,



▶ **Fig. 7** Case no. 6: Intraoperative perforation due to severe fibrosis. **a** Flat, elevated 16-mm lesion in the ascending cecum. **a** The diverticulum classification was type 2. **b** Severe fibrosis was present in the diverticulum. **c** Small submucosa remained due to fibrosis, and intraoperative perforation occurred. **d** After en bloc resection, the wound was completely closed with endoscopic clips. **e** The resected specimen.

surgical intervention including a laparoscopic endoscopy-guided procedure, may need to be considered as an alternative [32].

Our study has several limitations. First, because it was retrospective and observational, selection bias exists. Only lesions for which the technique was technically feasible may have been selected. Second, the number of cases included was small. Third, the results were obtained at a facility specializing in endoscopic procedures, making it difficult to generalize the results. Fourth, there was no direct comparison with other methods, such as conventional ESD or mechanical traction. Fifth, it is difficult to determine the effectiveness of WPM itself in only this study because strategic factors, such as what steps to take in the procedure, were involved. Further comparative interventional trials with larger numbers of patients are needed to evaluate the usefulness and safety of WPM for diverticulum-associated lesions.

Conclusion

In conclusion, the results of this study suggest the feasibility of ESD using WPM for diverticulum-associated lesions. This method might help to overcome lesions involving the diverticulum, although some cases may be complex.

Competing interests

The authors declare that they have no conflict of interest.

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