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Efficacy of Endoscopic Vacuum-Assisted Closure Treatment for Postoperative Anastomotic Leak in Gastric Cancer

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Background/Aims: Endoscopic vacuum-assisted closure (EVAC) has been attempted as new nonsurgical treatment for anastomotic leakage. We aimed to evaluate the clinical outcomes of EVAC and compare its efficacy with the self-expandable metallic stent (SEMS) for postgastrectomy leakage. **Methods:** Between January 2007 and February 2018, 39 patients underwent endoscopic treatment for anastomotic leakage after gastric cancer surgery. Of them, 28 patients were treated with SEMS, seven with EVAC after SEMS failure, and four with EVAC. We retrospectively compared the clinical characteristics and therapeutic outcomes between EVAC (n=11) and SEMS (n=28). **Results:** The median follow-up duration was 17 months (interquartile range, 9 to 26 months) in both groups. In comparison of clinical characteristics between two groups, only the median size of the leak was larger in the EVAC group than in the SEMS group (2.1 cm vs 1.0 cm; p<0.001). All EVAC cases healed successfully; however, two cases (7.1%) failed to heal in the SEMS group. Anastomotic stricture occurred one case (9.1%) in EVAC and four cases (14.3%) in SEMS within 1 year after endoscopic treatment. The median treatment duration of EVAC was shorter than that of SEMS (15 days vs 36 days; p<0.001). Median weight loss after therapy was similar in both groups (8.0 kg in EVAC vs 9.0 kg in SEMS; p=0.356). **Conclusions:** EVAC can be effective endoscopic treatment for postgastrectomy anastomotic leakage. Substantial leakage could be an important clinical factor for considering EVAC as a treatment option. Large randomized controlled trials are needed to confirm the efficacy of EVAC. **(Gut Liver 2020;14:746-754)**

Key Words: Vacuum assisted closure; Anastomotic leak; Gastrectomy; Self-expandable metallic stents; Stomach neoplasms

INTRODUCTION

Surgical resection is the only curative treatment for advanced gastric cancer or early gastric cancer that is not eligible for endoscopic submucosal dissection. Despite advances in surgical techniques, postoperative anastomotic leak is still the main reported adverse event, with an incidence rate of 0.7% to 7.5%[1-7] and mortality rate of 0.01% to 2.4%.[1,4,6,7] In postoperative anastomotic leak in upper gastrointestinal surgery, nonsurgical treatment or even conservative management has shown better outcomes than reoperation.[7] Endoscopic clipping, fibrin glue injection, and self-expandable metallic stent (SEMS) insertion have been used as nonsurgical endoscopic methods for the treatment of anastomotic leak,[8-12] however, the use of each modality has been limited by various clinical factors. Among those methods, SEMS insertion has been reported to have a favorable treatment success rate (>68.8% to 89.0%) for postoperative anastomotic leak in esophageal cancer.[13-17] However, adverse events after SEMS treatment have also been reported, such as migration, failure of stent extraction, and stricture formation after stent removal.[16-20] In recent years, endoscopic vacuum-assisted closure (EVAC) has been attempted as a new treatment option for postoperative fistula or anastomotic leak.[21] Several studies have reported the efficacy of EVAC in post-esophageal surgery, with a success rate of 84.4% to 86.4%.[22-24] By comparison, little has been reported on the efficacy of EVAC treatment for postgastrectomy anastomotic leak. In this study, we reviewed the clinical characteristics and therapeutic outcomes of patients who were treated with EVAC or SEMS for postgastrectomy anastomotic leak and

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compared the efficacy of EVAC with that of SEMS.

MATERIALS AND METHODS

1. Patients

Between January 2007 and February 2018, total 93 cases of anastomotic leak occurred after upper gastrointestinal tract surgery at Yonsei University Severance Hospital. Among them, 75 cases occurred after gastrectomy in gastric cancer surgery. Of them, 14 cases received the conservative management or reoperation, 22 cases were treated with clipping with or without fibrin glue or histoacryl, and 39 cases were treated with SEMS or EVAC. We retrospectively reviewed of 39 patients who underwent SEMS or EVAC for postoperative anastomotic leak. In our center, SEMS was the main treatment method for anastomotic leak from 2010 to 2015. Since October 2015 when the endoscopic vacuum therapy was introduced at our center, EVAC has been tried for anastomotic leak of upper gastrointestinal tract and mainly performed to the cases that failed with SEMS. Since the end of 2016, EVAC has been used in an initial treatment of anastomotic leak for some cases that endoscopists judged unsuitable for mounting SEMS, such as a large leak size or a structural deformation at subtotal gastrectomy (STG).

Among a total of 39 patients, 28 cases were treated with SEMS and 11 cases with EVAC. For the EVAC cases, four cases were treated with EVAC alone and seven cases were switched from SEMS to EVAC during treatment because they were suspected of treatment failure. We compared the clinical characteristics and therapeutic outcomes between the EVAC group (n=11) and the SEMS group (n=28).

2. Assessment of leak diagnosis and treatment outcome

When clinical symptoms such as abdominal pain, increasing amount of drainage, fever, leukocytosis, and elevation of C-reactive protein level occurred after surgery, anastomotic leak was suspected. Further, radiological examinations (abdominal computed tomography [CT], esophagography) and endoscopy were performed to confirm the leak. Radiologic findings indicative of leak were defined as extraluminal extravasation of contrast medium on fluoroscopy or CT or the presence of infiltration around the anastomosis site with or without fistula tract formation on CT. Endoscopic treatment was performed only if leak was confirmed on endoscopy.

The primary endpoint was the success or failure of leak closure. Successful leak closure was defined as no evidence of the leak on the radiologic or endoscopic image after device removal, and no clinical sign of persistent leak. The therapeutic outcomes were evaluated using the following factors: success rate of leak closure, leak-related mortality, duration of therapy, repositioning or replacement count of stent or vacuum, weight loss after treatment, antibiotics use, and incidence rate of stricture within 1 year. The duration of therapy was defined as the number of days from device insertion to removal. Leak-related mortality was defined as death of the patient before the confirmation of leak closure without other causes of death.

3. Endoscopic SEMS

In all patients, the endoscopic procedure was performed under sedation, using standard upper gastrointestinal endoscopes (GIF Q260 and H260, 290; Olympus, Tokyo, Japan), with fluoroscopic assistance. The endoscopist first checked the location of the anastomotic leak through the endoscope and then injected contrast dye to the leak site. If the dye passed through the leak, the size of the leak was measured based on the diameter of the endoscope. After the leak was confirmed on endoscopy, the location of the leak was marked using radiopaque material attached on the patient's skin, and the guidewire was passed into the endoscope channel. Then, the stent was inserted along the guidewire and deployed over the leak area under the guidance of radiofluoroscopic imaging. We usually use Shim's technique to prevent the migration of the stent.[25] According to Shim's technique, the stent was fixated using a silk thread covered with a 14-F rubber tube. The end of the silk thread was attached to the proximal edge of stent and connected to the patient's earlobe via the nostril.[25] Endoscopy was repeated at 1 to 2 weeks after insertion, and if there was no migration, the external fixation was removed. The stent position was checked with abdominal X-ray at the day after the procedure and every 1 to 2 weeks until the stent was stabilized. If the migration of stent was suspected on X-ray or the patient's symptom was aggravated, endoscopic evaluation was performed any time and the stent was changed or repositioned if needed. The nutritional support was provided by total parenteral nutrition (TPN) first and switched to per oral intake at 2 to 3 days after stent insertion. The stent was removed within 4 to 8 weeks and complete closure of the anastomotic leak was confirmed with endoscopy with fluoroscopy and/or with CT or esophagography after stent removal.

4. Endoscopic vacuum-assisted closure

In all patients, the endoscopic procedure was performed under sedation, using standard upper gastrointestinal endoscopes (GIF Q260 and H260, 290; Olympus), with fluoroscopic assistance. The endoscopist first checked the location of the anastomotic leak through the endoscope and then injected a contrast dye to the leak site. If the dye passed through the leak, the size of the leak was measured based on the diameter of the endoscope. Two expert endoscopists (J.C.P. and S.K.L.) performed the endoscopic interventions.

After the assessment of the leak size and location, a polyurethane foam sponge (e.g., CuraVAC®; CGBio Inc., Seongnam, Korea) was cut by the endoscopist into the adequate size and shape. To apply negative suction pressure through the sponge,

additional 1 to 2 mm side holes were made at the nasogastric (NG) tube tip by using scissors. Then, the NG tube tip was placed into one nostril and extracted out through the oral cavity by using alligator forceps (MTW Endoskopie, Wesel, Germany). Size-adjusted (15 to 30 mm) polyurethane sponge was anchored at the NG tube tip by suture with a 3-way nylon thread. Then, the NG tube tip with sponge was gripped with alligator forceps and pushed into the necrotic portion of the leak site through the endoscopic view (Fig. 1A and B). The sponge was buried in the hole to completely cover with the area of cavity. After positioning, the outside part of the NG tube was fixed at the patient's nose by taping. Finally, the outside tip of the NG tube was connected to an electronic vacuum device (KCI V.A.C. Freedom®; KCI USA Inc., San Antonio, TX, USA; setting: −125 mm Hg, continuous, and high intensity), and continuous suction pressure (100 to 125 mm Hg) was generated. We evaluated the wound status through endoscopy at weekly intervals until the wound cavity seemed to be firmly closed. If the sponge size and position were considered appropriate on the endoscopy, the sponge was not changed and re-fixed in the same position. If the sponge size became larger than the leak size according to wound healing, the previous sponge was removed and the resized sponge was newly inserted. If the clinical symptom was aggravated or if sponge migration was suspected on X-ray, endoscopic evaluation was performed earlier than the regular schedule. EVAC therapy was terminated when the leak size became too small to place further sponge or the granulation tissue was filled up enough the hole (Fig. 1C). Complete healing of the leak was evaluated using endoscopy with fluoroscopy and/or CT or esophagography. The initial nutritional supplement was provided through TPN and switched to enteral feeding after the EVAC sponge was removed.

5. Switching to EVAC from endoscopic SEMS

The endoscopist considered switching SEMS to EVAC in the following conditions: if the leak hole was not changed on the subsequent endoscopy after SEMS insertion (Fig. 2), if the drain of Hemovac® (Zimmer Surgical, Inc., Dover, OH, USA) was continuously turbid, if the clinical inflammation signs were not improved (fever, elevation of C-reactive protein, etc.), or if the reposition or replacement of the stent was needed more than two times.

6. Statistical analysis

Data are presented as medians with ranges for continuous variables and as numbers for categorical variables. Continuous variables were evaluated using the Mann-Whitney test. Categorical variables were evaluated with the chi-square test or

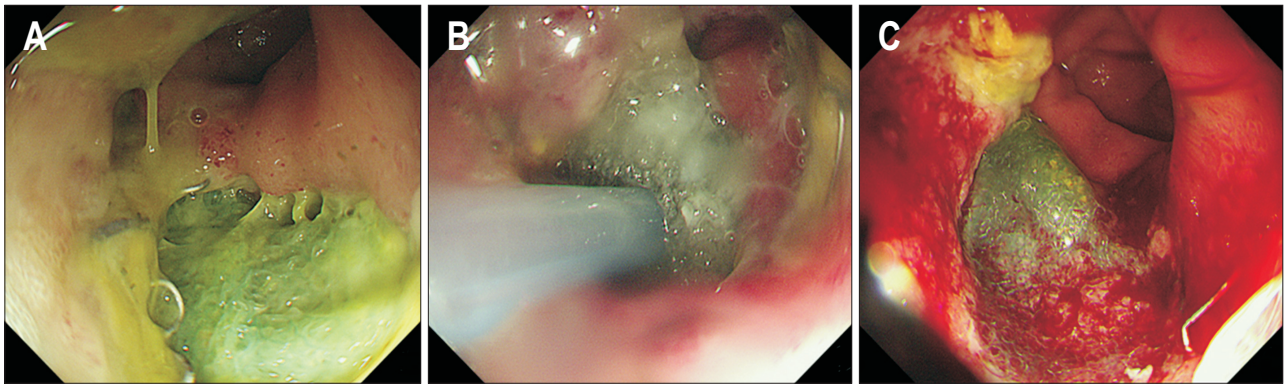

Fig. 1. Case treated with endoscopic vacuum-assisted closure (EVAC) only. (A) Anastomotic leakage after Billroth I surgery was detected. (B) An EVAC sponge was inserted at the leakage site. (C) After 2 weeks, granulation tissue formed at the leakage hole.

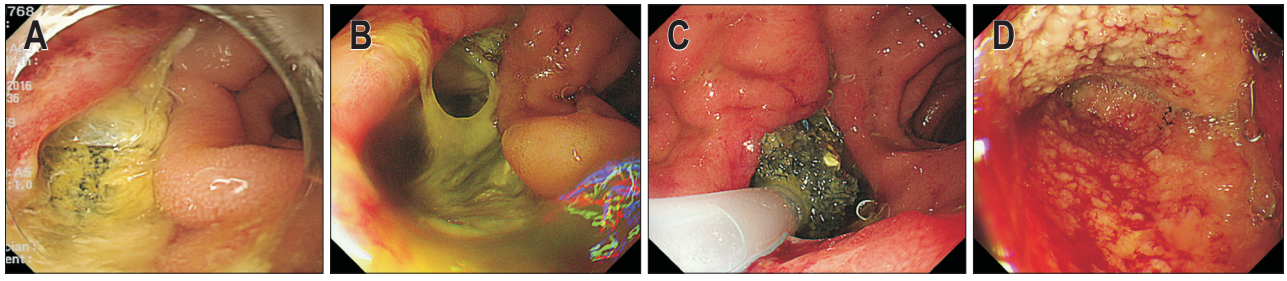

Fig. 2. Case treated with endoscopic vacuum-assisted closure (EVAC) after the failure of self-expandable metallic stents (SEMSs). (A) Anastomotic leakage was detected after Billroth I surgery and SEMS was initially inserted. (B) After 2 weeks, leakage was still observed without significant changes. (C) A sponge was prepared and mounted into the hole by using alligator forceps. (D) After 13 days, healing with granulation tissue was seen after EVAC sponge removal.

Fisher exact test because of small sample sizes.

Statistical analysis was performed using IBM SPSS software, version 23.0 for Windows (IBM Corp, Armonk, NY, USA). All statistical tests were two-sided, and a value of $p<0.05$ was considered statistically significant.

RESULTS

1. Characteristics of patients

Of 39 patients, 11 cases were treated with EVAC and 28 cases were treated with SEMS. Seven cases of EVAC-treated patients were the cases of changed from SEMS to EVAC due to no improvement in clinical symptoms. The other four cases were initially treated with EVAC because the clinician determined that EVAC therapy was appropriate for the lesions. The clinical characteristics of the 39 patients (11 of EVAC group, 28 of SEMS group) are shown in Table 1. Age, American Society of Anesthesiologists score, underlying comorbidities, anticoagulant or antiplatelet agents use, type of surgery, TNM stage, and preoperative body mass index showed no statistically significant differences between two groups. Only the median size of leak was larger in EVAC group than SEMS group ($p<0.001$).

2. Therapeutic outcome of patients

The median follow-up duration were 11 months (interquartile range [IQR], 1.0 to 17.0 months) in EVAC group and 19.5 months (IQR, 10.3 to 35.0 months) in SEMS group. The therapeutic outcomes of each treatment are shown in Table 2, and detailed data of the EVAC group are shown in Table 3.

All cases of EVAC were treated successfully without mortality (11/11, 100%). In comparison, there were two cases of treatment failure (2/28, 7.1%) including one case of mortality (1/28, 3.6%) in SEMS group. One patient died of a leak associated infectious complication on the 23rd day after stent insertion without clinical improvement. The other patient removed stent on 17th day of insertion due to exacerbation of clinical inflammatory symptom and sign. After stent removal, the leak was still confirmed, however, the patient refused further treatment and expired 9 months later.

The success rate of SEMS was 92.9% (26/28), however, when the seven cases, which switched from SEMS to EVAC, were considered as SEMS failure, the success rate of SEMS was 74.3% (26/35).

The duration of therapy in EVAC group was significantly shorter than SEMS group (median, 15 days [IQR, 6 to 21 days] vs 36 days [IQR, 28 to 48 days]; $p<0.001$).

In the number of reposition or replacement procedures, there were five cases in EVAC due to sponge migration out or hole size change (5/11, 45.5%) and seven cases in SEMS due to stent migration (7/28, 25.0%; $p=0.262$).

In calculating the weight change from the time of admission to the first outpatient department visit on discharge, the median weight loss was no significant difference between two groups (median, 8.0 kg [IQR, 4.0 to 11.0 kg] in EVAC group vs 9.0 kg [IQR, 7.0 to 12.0 kg] in SEMS group; $p=0.356$).

All patients received antibiotic therapy during procedure. The antibiotics were started immediately when the leak was confirmed or clinically suspected, and continued until the leak was completely closed. However, one case that switched to EVAC from SEMS stopped the antibiotic during EVAC therapy

Table 1. Comparison of Clinical Characteristics between the EVAC and SEMS Groups Treated for Anastomotic Leakage

Characteristic	Total (n=39)	EVAC (n=11)	SEMS (n=28)	p-value
Age, yr	66.0 (39–82)	68.0 (55–81)	63.5 (39–82)	0.450
ASA				
1 or 2	24 (61.5)	6 (54.5)	18 (64.3)	0.718
3 or 4	15 (38.5)	5 (45.5)	10 (35.7)	0.718
Cardiovascular disease	23 (59.0)	9 (81.8)	14 (50.0)	0.086
Diabetes mellitus	10 (25.6)	4 (36.4)	6 (21.4)	0.424
Use of anticoagulant or antiplatelet agent	14 (35.9)	6 (54.5)	8 (28.6)	0.156
Type of surgery				
Total or proximal gastrectomy	28 (73.7)	6 (54.5)	22 (78.6)	0.234
Billroth I or II	11 (28.2)	5 (45.5)	6 (21.4)	0.234
TNM stage				
1 or 2	27 (69.2)	9 (81.8)	18 (64.3)	0.446
3 or 4	12 (30.8)	2 (18.2)	10 (35.7)	0.446
Preoperative BMI, kg/m^2	24.5 (21.2–26.4)	23.8 (19.8–25.4)	24.6 (22.1–26.5)	0.363
Size of leak, cm	1.5 (1.0–2.0)	2.1 (2.0–3.0)	1.0 (0.8–1.5)	<0.001

Data are presented as median (interquartile range) or number (%).
EVAC, endoscopic vacuum-assisted closure; SEMS, self-expandable metallic stent; ASA, American Society of Anesthesiologists; BMI, body mass index.

Table 2. Comparison of Therapeutic Outcomes between EVAC and SEMS for Anastomotic Leakage

Outcomes	Total (n=39)	EVAC (n=11)	SEMS (n=28)	p-value
Follow-up duration, mo	17.0 (9.0–26.0)	11.0 (1.0–17.0)	19.5 (10.3–35.0)	0.043
Successful closure	37 (94.9)	11 (100.0)	26 (92.9)	>0.999
			26 (74.3)*	0.089*
Leak-related mortality	1 (2.6)	0	1 (3.6)	>0.999
Duration of therapy, day	31.0 (15.0–46.0)	15.0 (6.0–21.0)	36.0 (28.0–48.0)	<0.001
Stent/sponge change or replacement	12 (30.8)	5 (45.5)	7 (25.0)	0.262
Weight loss after treatment, kg†	9.0 (6.8–12.0)	8.0 (4.0–11.0)	9.0 (7.0–12.0)	0.356
Antibiotics use				
Antibiotics cessation	1 (2.6)	1 (9.1)	0	0.282
Antibiotics duration, day	24.0 (16.0–36.0)	29.0 (15.0–47.0)	23.5 (16.3–34.5)	0.731
Antibiotics step-up	11 (43.6)	0	11 (39.3)	0.017
Antibiotics step-down	3 (7.7)	2 (18.2)	1 (3.6)	0.187
Incidence rate of stricture within 1 yr	5 (12.8)	1 (9.1)	4 (14.3)	>0.999

Data are presented as median (interquartile range) or number (%).
EVAC, endoscopic vacuum-assisted closure; SEMS, self-expandable metallic stent.
*Value when seven cases were switched from SEMS to EVAC and classified as SEMS failure; †Except one mortality case.

Table 3. Detailed Review of Patients Treated with EVAC

Patient No.	Sex/age, yr	SEMS before EVAC	Operation	TNM stage/ pathology	Size of leak, cm	Success to closure	Duration of SEMS, day	Duration of EVAC, day	EVAC change	Follow-up, day	Stricture within 1 yr
1	M/68	Yes	PG with DTR	T1bN0 AWD	2.0	Yes	46	16	Yes	362	No
2	M/56	Yes	TG with RY	T1bN0 AMD	2.1	Yes	6	15	No	361	No
3	M/74	Yes	PG with DTR	T1bN0 AMD	2.5	Yes	12	21	Yes	523	No
4	M/55	Yes	PG with DTR	T1aN0 AMD	3.0	Yes	21	6	No	748	No
5	M/58	Yes	PG with DTR	T1bN0 APD	3.3	Yes	38	15	Yes	718	Yes
6	M/80	Yes	TG with RY	T4N3 APD	2.0	Yes	16	23	Yes	530	No
7	M/81	Yes	STG-BI	T1bN1 APD	3.0	Yes	12	13	No	246	No
8	F/65	No	STG-BI	T1aN0 SRC	2.0	Yes	NA	6	No	27	No
9	M/63	No	STG-BI	T1bN0 AMD	2.5	Yes	NA	13	No	367	No
10	F/68	No	STG-BII	T4N3 APD	2.0	Yes	NA	17	Yes	30	No
11	M/70	No	STG-BI	G3N0 NET	1.5	Yes	NA	6	No	55	No

EVAC, endoscopic vacuum-assisted closure; SEMS, self-expandable metallic stent; M, male; F, female; PG, proximal gastrectomy; DTR, double tract reconstruction; TG, total gastrectomy; RY, Roux-en Y esophagojejunostomy; STG-BI, subtotal gastrectomy with gastroduodenostomy; STG-BII, subtotal gastrectomy with gastrojejunostomy; AWD, adenocarcinoma, well-differentiated; AMD, adenocarcinoma, moderately differentiated; APD, adenocarcinoma, poorly differentiated; SRC, signet ring cell carcinoma; NET, neuroendocrine tumor; NA, not available.

and achieved the leak healing without further antibiotic use. The duration of antibiotic use showed no significant difference between two groups (median, 29.0 days [IQR, 15.0 to 47.0 days] in EVAC group and 23.5 days [IQR, 16.3 to 34.5 days] in SEMS group; p=0.731). Within a certain period of time after the procedure, when the patient's signs of infection were not improved such as sustained of fever, leukocytosis, or C-reactive protein elevation, the clinicians usually decided to give step-up antibiotic therapy. In SEMS group, 11 patients received step-up antibiotic therapy during the treatment period (11/28, 39.3%). In comparison, in EVAC group, all patients did not receive step-up antibiotic therapy during the treatment period.

After the therapy, five cases of anastomosis site stricture occurred during follow-up period. All cases developed within 1 year. In the EVAC group, one case of anastomotic stricture occurred (1/11, 9.1%) at 147 days after EVAC removal. He underwent two sessions of through-the-scope endoscopic dilations, and the clinical symptom resolved without adverse events or sequelae (Fig. 3). In the SEMS group, four cases of anastomotic stricture occurred (4/28, 14.3%) at a median of 102 days (IQR, 41.3 to 270.8 days) after SEMS removal. The details of each case are described in Table 4.

DISCUSSION

EVAC was first introduced as a treatment for anastomotic leak after rectal surgery.[21] Since the first report of its application in the upper gastrointestinal tract,[26,27] several centers have reported the feasibility and efficacy of EVAC management.[22,24,28-30] However, most of those studies focused on esophageal cancer surgery, and there have been very few studies on leak treatment after gastric cancer surgery. To the best of our knowledge, this is the first study to report the clinical outcome of EVAC focusing in the treatment of postgastrectomy anastomotic leak in gastric cancer.

In our study, there was no significant difference in success rate between EVAC and SEMS. However, the duration of EVAC therapy was significantly shorter than that of SEMS therapy even if the leak size was larger in the EVAC group than in the SEMS group. Concerning the treatment mechanism, SEMS insertion simply blocks the leak site until the healing of the leak, but EVAC drains the necrotic debris and pus in the leak site with negative pressure.[21] Therefore, EVAC can prevent the local spread of inflammation, and induce vascular perfusion and granulation tissue formation. These advantages may be related to the rapid healing process after EVAC.

In previous studies, a leak size of >2 cm has been suggested

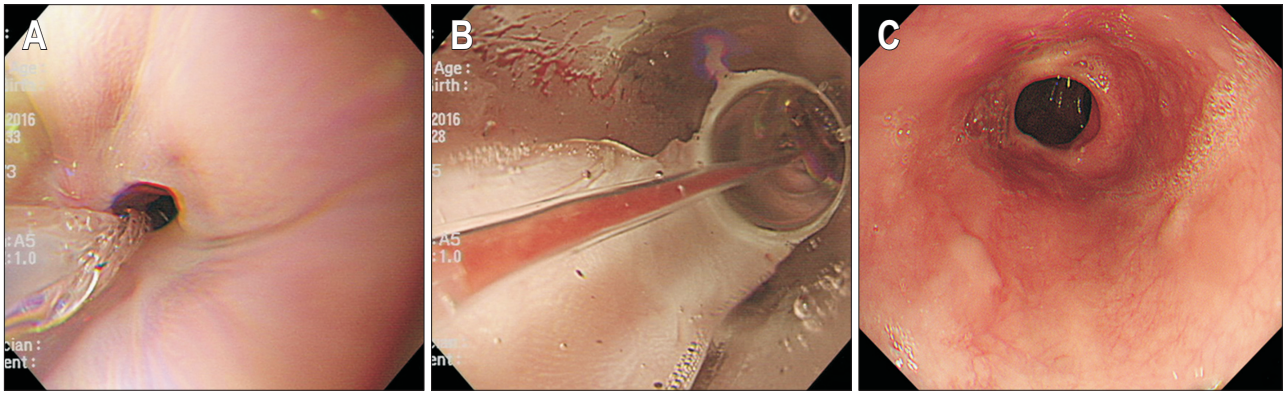

Fig. 3. A case of stricture development after treatment. (A) Anastomosis site stricture occurred at 147 days after leakage healing. (B) Two through-the-scope endoscopic dilations were done at an interval of 3 months. (C) The symptoms were relieved 2 weeks later after the last procedure, and an improved state of stricture was confirmed with endoscopy 1 year later.

Table 4. Comparison of Stricture Cases in EVAC and SEMS

Patient No.	Sex/age, yr	Leak treatment	Duration of leak treatment, day	Time interval of stricture, day	TTS management counts	Management interval, mo	Follow-up, day	Symptom
1	M/61	SEMS	21	126	3	7, 12	750	Improved but still remained
2	M/74	SEMS	46	78	3	1, 2	808	Resolved
3	F/66	SEMS	28	29	3	1, 4	286	Follow-up loss*
4	M/48	SEMS	35	319	1	NA	380	Follow-up loss*
5	M/58	SEMS→EVAC	38, 15	147	2	3	718	Resolved

EVAC, endoscopic vacuum-assisted closure; SEMS, self-expandable metallic stent; TTS, through the scope; M, male; F, female; NA, not available.
*Follow-up loss after the last procedure.

to indicate the failure of endoscopic treatment.[12] In our study, the median leak size of 11 patients who were successfully treated with EVAC was 2.1 cm (IQR, 2.0 to 3.0 cm). Among them, seven patients had a leak size of ≥2 cm and three patients had a leak size of ≥3 cm. By comparison, in the 26 patients who were successfully treated with SEMS, the median leak size was 1.0 cm (IQR, 0.8 to 1.5 cm), and among them, particularly two patients with a leak size more than 2 cm were treated for relatively longer period (46 days each). Generally, a large leak needs more time to achieve for granulation tissue formation and leak closure. As mentioned above, EVAC may shorten this period through its therapeutic mechanism.

A total of 11 cases of leak occurred after STG. One of them was successfully treated with EVAC after SEMS failure. Since then, the four subsequent cases of leak occurring after STG were initially treated with EVAC without SEMS because the endoscopist judged that EVAC could be better than SEMS. They were successfully treated with a median treatment duration of 9.5 days (IQR, 6.0 to 38.5 days). In other six patients who were treated with SEMS alone, the median treatment duration was 36.5 days (IQR, 16.3 to 63.0 days). Because the remnant stomach should be connected with small bowel, the channel at anastomosis site in the STG is wider and more curved than in the total gastrectomy. If the stent is inserted in this condition, a free space is formed between the stent and mucosa, and it is difficult to cover the leak area completely. However, because the shape and size of sponge can be controlled in EVAC, it can be directly inserted into the leak area and mounted at the hole. Therefore, EVAC may be less affected by postoperative structural change and have an advantage for STG cases.

Previous studies on EVAC therapy recommended vacuum sponge replacement every 3 to 7 days[31,32] because the size of the leak cavity changes according to ingrowth of granulation tissue.[33] Such frequent repetition of the endoscopic procedure was one of the limitations of EVAC therapy. In our study, we performed endoscopy at intervals of 1 to 2 weeks to check the leak state and if the sponge was adequate for size of the hole in endoscopic view, we did not change the sponge. Among 11 cases of EVAC, six cases were treated successfully without sponge change during a median of 9.5 days (IQR, 6.0 to 13.5 days).

All patients started to use antibiotics when the leak was strongly suspected to complicated by intra-abdominal infection. They maintained antibiotics until the treatment was completely finished, except for one patient, who ceased the antibiotics on the first day after switching to EVAC from SEMS. He achieved healing without further antibiotics use. During the antibiotics use, the clinician considered antibiotic step-up if the clinical symptom did not improve after the procedure (usually within 2 to 3 days). In SEMS group, 11 of 28 patients received antibiotic step-up. By comparison, all patients of EVAC group were treated without antibiotic step-up. Among four patients who had received antibiotic step-up during SEMS therapy, two patients received antibiotic step-down during EVAC period. Moreover, although there was no statistically significant difference, in the SEMS group, 28.6% (8/28) of patients terminated antibiotics within 10 days prior to SEMS removal, whereas in the EVAC group, 54.5% (6/11) of patients terminated antibiotics within 10 days prior to EVAC removal. Although the effect of previous SEMS therapy should be considered, it is expected that EVAC therapy may reduce antibiotics use through therapeutic mechanisms. However, more large-scaled prospective study will be needed for confirmation.

Pathophysiologically, local inflammation during the intestinal healing process may be related to the occurrence of stricture.[34] As mentioned above, the local inflammation is expected to be more in SEMS than EVAC. In addition, bleeding and ulceration can occur when SEMS is extracted, due to tissue hyperplasia and mucosal embedding at the stent tip.[35] However, EVAC can minimize the contact area between the sponge and the normal mucosa through the size and shape adjustable, which can lower the incidence of posttreatment stricture in EVAC compared than SEMS.

In the previous studies, the nutritional support in EVAC therapy was done by TPN until the sponge was removed. In SEMS therapy, enteral feeding is possible within 1 to 2 days after. In our center, the patients with SEMS started enteral feeding within a week after stent insertion, and the patients with EVAC were supplied only TPN during therapy. To find the nutritional difference, we compared the body weight at pre-operation and at first outpatient visit after discharge. In this study, there was no significant difference between the two groups. This suggests that although enteral feeding is delayed in EVAC, nutritional disadvantage may not be large. However, there should be large-scaled studies for the investigation of the nutritional aspect.

This study has some limitations. First, this study was not a randomized controlled trial and the number of cases in each group was relatively small. Second, the cases that changed to EVAC from SEMS were included in EVAC group. Although these changes were made when SEMS treatment was considered to have failed, it is difficult to completely exclude the effect of SEMS on treatment extension.

Despite these limitations, we believe that our study presents the effectiveness of EVAC in a treatment technique of anastomotic leak after gastric cancer resection. Our study suggests a clinical situation in which EVAC can be considered first.

In conclusion, EVAC can be another useful treatment option in the postgastrectomy anastomotic leak. Based on this study, we hope that further large prospective and comparative studies for SEMS and EVAC will be conducted to establish an efficient treatment for anastomotic leak after gastrectomy.

CONFLICTS OF INTEREST

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

AUTHOR CONTRIBUTIONS

Study concept and design: J.C.P., S.K.S., S.K.L., Y.C.L. Data acquisition: S.I.C., D.H.J. Statistical analysis: S.I.C. Data analysis and interpretation: S.I.C. Drafting of the manuscript: S.I.C. Critical revision of the manuscript for important intellectual content: J.C.P., S.K.S., S.K.L., Y.C.L.

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