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Risk Factors of Anastomosis Stricture After Esophagectomy and the Impact of Anastomosis Technique

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ABSTRACT

BACKGROUND Anastomosis complications after esophagectomy are related to postoperative survival and quality of life. This is a retrospective observational study to identify risk factors for anastomotic stricture after esophageal cancer surgery and the effect of different anastomosis techniques on stricture development.

METHODS This study included 737 patients who underwent esophagectomy for esophageal cancer that used stomach conduits. Four types of anastomoses were used: manual sewing (n = 221, 30%), circular stapling (n = 172, 23%), hybrid linear stapling with a 45-mm stapler (HLS; n = 155, 21%), and triangular linear stapling with 60-mm staplers (TLS; n = 189, 26%). Multivariate analysis was performed to evaluate the risk factors for stricture.

RESULTS Strictures that required endoscopic dilatation within 1 year after surgery occurred in 105 patients (14%), and 13% of the strictures were related to leakage. Multivariate analysis revealed that chronic obstructive pulmonary disease (hazard ratio [HR] 1.726, $P = .017$), leakage (HR 2.502, $P = .015$), and anastomosis techniques other than TLS (manual sewing: HR 9.588; circular stapling: HR 6.516; HLS HR 5.462, all $P < .001$) were significant risk factors for stricture. TLS significantly reduced the stricture rate (3.2%) compared with other techniques (manual sewing: 22.2%; circular stapling:, 14.5%; HLS: 16.1%; $P < .001$). Stricture rate was lower in the TLS group in patients without leakage ($P < .001$); however, the effect disappeared with leakage.

CONCLUSIONS Anastomosis stricture occurred in 14% of esophagectomy patients. Chronic obstructive pulmonary disease, leakage, and anastomosis technique are risk factors for stricture. A large anastomosis area with the TLS technique using 60-mm length linear staplers prevented stricture, especially when leakage was not observed.

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Esophageal cancer is the eighth most common cancer worldwide; however, it ranks sixth among all cancer mortalities due to its poor survival rate.[1] Surgery is the mainstay of treatment, and anastomosis of the remnant esophagus and conduit is the critical phase of esophagectomy. Anastomosis stricture after esophageal cancer surgery is a common complication and varies in incidence ranging from 9.1% to 46%.[2,3] Postoperative stricture can seriously affect a patient's quality of life and worsen body weight loss after esophagectomy due to poor nutrition. Several factors have been reported as risk factors for postoperative stricture after esophagectomy. One of the important factors of stricture is the anastomosis

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technique, because it is a modifiable factor, unlike other fixed risk factors caused by the underlying disease status. In addition to conventional end-to-end hand-sewn techniques, many different anastomosis techniques incorporating circular staplers or linear staplers have been introduced, and most of these techniques have been used in our institute.

In this study, we aimed to identify the risk factors of postoperative stricture in esophagectomy patients and the effect of the different anastomosis techniques on the development of the stricture, which can guide the selection of the optimal anastomosis technique to prevent stricture.

PATIENTS AND METHODS

This study was approved by the institutional review board, and patient consent was waived (Approval No.

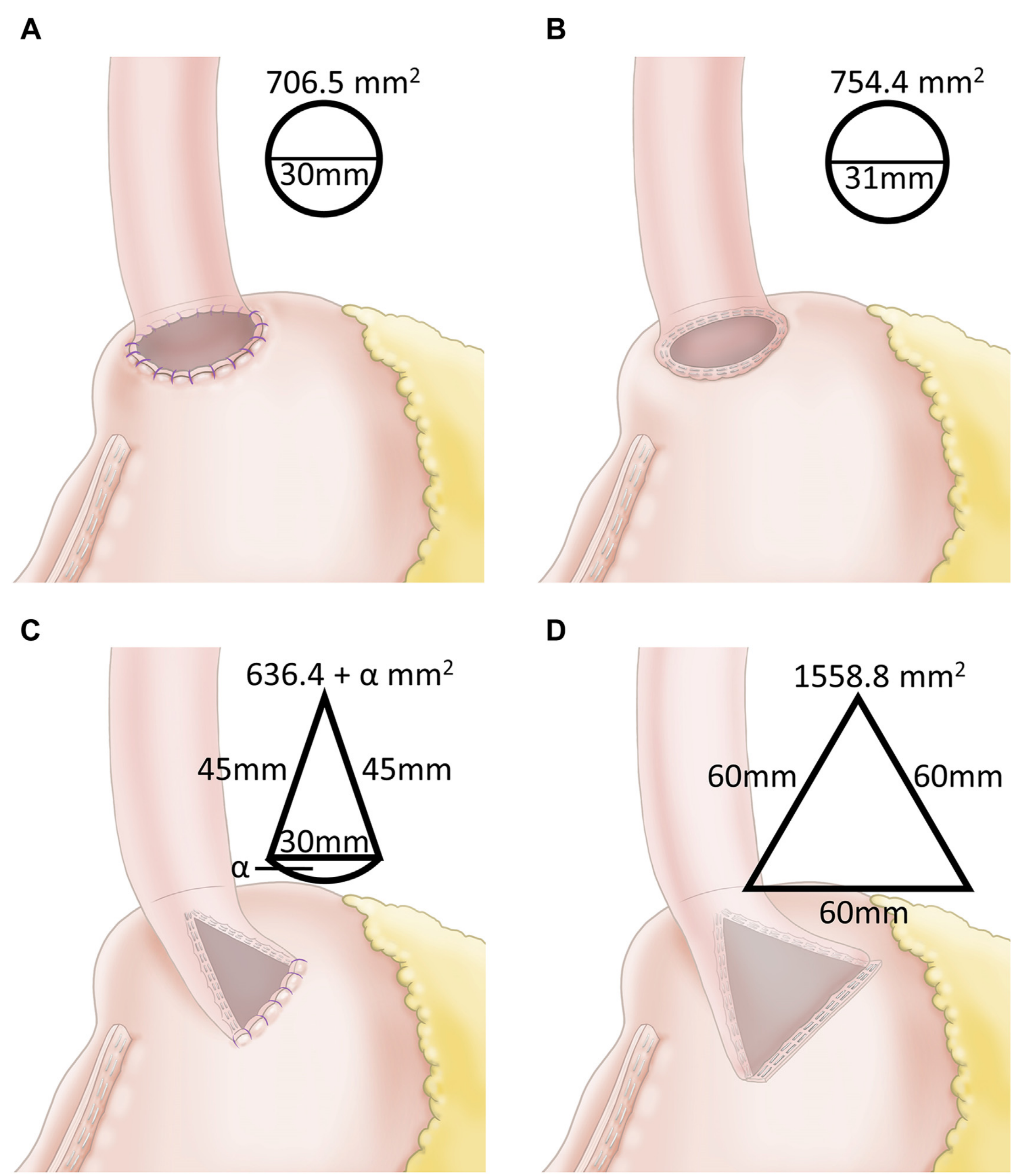

FIGURE 1 (A) Manual sewing type anastomosis and presumed cross-sectional area (CSA). (B) Circular stapling type anastomosis and presumed CSA. (C) Hybrid linear stapling type anastomosis with a 45-mm length stapler and presumed CSA. (D) Triangular linear stapling type anastomosis with 60-mm length staplers and presumed CSA.

TABLE 1 Demographic Data

Factor	Value
Sex	
Male	686 (93.1)
Female	51 (6.9)
Age, y	64.3 ± 8.4
Body mass index, kg/m^2	23.0 ± 3.1
Smoking status	
Never smoker	126 (17.1)
Exsmoker	462 (62.7)
Current smoker	149 (20.2)
ECOG Performance status	
0	492 (66.8)
1	233 (31.6)
2	12 (1.6)
Preoperative comorbidity	
Hypertension	280 (38.0)
Chronic obstructive pulmonary disease	270 (36.6)
Diabetes mellitus	135 (18.3)
Liver disease	41 (5.6)
Ischemic heart disease	44 (6.0)
Stroke history	40 (5.4)
Peripheral vascular disease	19 (2.6)
Renal disease	14 (1.9)
Previous cancer history	86 (11.7)
Previous abdominal surgery history	75 (10.2)
Previous chest surgery history	15 (2.0)
Tumor location	
Cervical	13 (1.8)
Upper thoracic	91 (12.3)
Mid thoracic	456 (61.9)
Lower thoracic	177 (24.0)
Squamous cell carcinoma	700 (95.0)
Stage	
I	258 (35.0)
II	262 (35.5)
III	155 (21.0)
IV	59 (8.0)
0	3 (0.4)
Preoperative chemoradiation[a]	155 (21.0)
Adjuvant chemotherapy	132 (17.9)
Adjuvant radiotherapy	74 (10.0)

[a]Preoperative chemoradiation includes esophagectomy after neoadjuvant chemoradiation and salvage esophagectomy after definitive chemoradiation. Results are provided as n (%) or mean ± SD. ECOG, Eastern Cooperative Oncology Group.

H-2201-129-1294; approval date: February 3, 2022). We retrospectively analyzed 737 patients with pathologically proven esophageal cancer who were treated with transthoracic or transhiatal esophagectomy and posterior mediastinal reconstruction using stomach conduit from 2003 to 2019 who survived the first postoperative month. Patients who had a previously resected stomach were not included. Demographic data included sex, age, body mass index, smoking history, performance status, preoperative comorbidity, tumor location, histologic type, stages, preoperative chemoradiation, and type of adjuvant therapy. Clinical staging was evaluated according to the 8th edition of the American Joint Committee on Cancer staging system. Data on surgical procedures were reviewed under the headings of anastomosis location, minimally invasive esophagectomy, and anastomosis methods. Data about postoperative complications were also included. All patients were evaluated routinely by esophagography on postoperative day 7. The presence of stricture was defined as the experience of endoscopic dilatation due to dysphagia or weight loss accompanied by radiologic or endoscopic narrowing within the first postoperative year, according to previous studies.[4,5] No prophylactic dilation was performed for leakage patients. Routine follow-up in the outpatient clinic after discharge was performed in the second week, first month, and at months 3, 6, 9, and 12 after discharge. Postoperative endoscopic surveillance was performed immediately if a patient complained of dysphagia or was performed routinely 1 year after surgery if asymptomatic.

TABLE 2 Surgical Data and Postoperative Complication Data

Factor	Value
Anastomosis location	
Cervical	378 (51.3)
Thoracic	359 (48.7)
Minimally invasive esophagectomy	342 (46.4)
Anastomosis methods	
Triangular linear stapling	189 (25.6)
Hybrid linear stapling	155 (21.0)
Circular stapling	172 (23.3)
25 mm	31 (18.0 of CS)
28 mm	131 (76.2 of CS)
31 mm	10 (5.8 of CS)
Manual sewing[a]	221 (30.0)
Postoperative leakage	43 (5.8)
Postoperative chyle leakage[b]	55 (7.5)
Respiratory complication	81 (11.0)
Cardiac complication	14 (1.9)
Gastrointestinal complication	11 (1.5)
Urinary complication	10 (1.4)
Neurologic complication	87 (11.8)
Infectious complication	47 (6.4)

[a]Manual sewing includes hand sewing and robotic sewing; [b]Postoperative chyle leakage includes chyle leakage in the chest, abdomen, and neck. Values are presented as n (%). CS, circular stapling.

ANASTOMOSIS TECHNIQUE. Four different types of anastomoses were performed at our institute (Figure 1): manual sewing (MS), circular stapling (CS), hybrid linear stapling with a 45-mm length stapler (HLS), and triangular linear stapling with 60-mm length staplers (TLS). The MS included both hand sewing and robotic sewing techniques. The hand sewing technique was conducted mainly by end-to-end anastomosis using double layers of 4-0 polyglactin 910 (Vicryl, Ethicon)

TABLE 3 Univariate Analysis I for The Risk Factors of Anastomosis Stricture

Risk factors	Hazard Ratio	95% CI	*P* Value
Male sex	0.885	0.404-1.940	.76
Age ≥70 y	0.913	0.573-1.456	.70
Body mass index ≤20	1.015	0.593-1.736	.96
Smoking status (linear)			.46
Never smoker	1		
Exsmoker	0.972	0.560-1.687	.92
Current smoker	0.774	0.387-1.548	.47
ECOG performance status (linear)			.27
0	1		
1	1.386	0.902-2.131	.14
2	0.608	0.077-4.789	>.99
Hypertension	1.005	0.657-1.538	.98
Chronic obstructive pulmonary disease	1.702	1.123-2.582	.01
Diabetes mellitus	0.841	0.482-1.468	.54
Liver disease	0.460	0.139-1.517	.19
Ischemic heart disease	0.947	0.390-2.300	.91
Stroke history	1.297	0.558-3.013	.55
Peripheral vascular disease	2.207	0.778-6.262	.17
Renal disease	1.003	0.221-4.548	>.99
Previous cancer history	1.716	0.974-3.024	.06
Previous abdominal surgery history	0.918	0.456-1.850	.81
Previous chest surgery history	0.424	0.055-3.262	.71
Tumor location			.01
Cervical	1		
Upper thoracic	4.059	0.500-32.949	.29
Mid thoracic	1.680	0.214-13.169	>.99
Lower thoracic	1.974	0.246-15.852	>.99
Preoperative chemoradiation[a]	0.806	0.473-1.371	.43
Adjuvant chemotherapy	0.800	0.453-1.413	.44
Adjuvant radiotherapy	1.186	0.616-2.286	.61

[a]Preoperative chemoradiation includes esophagectomy after neoadjuvant chemoradiation and salvage esophagectomy after definitive chemoradiation. ECOG, Eastern Cooperative Oncology Group.

and black silk. In robotic sewing, we used 3-0 barbed sutures (V-Loc, Medtronic) for continuous double-layered sutures. CS was conducted using DST SERIES EEA 25 mm, 28 mm, or 31 mm staplers (Medtronic). HLS utilizes a modified Orringer technique.[4] The posterior wall was stapled with a 45-mm stapler (Endo GIA Articulating Reload with Tri-Staple Technology 45 mm medium/thick, Medtronic), and the anterior wall was sutured manually. TLS is a side-to-side esophagogastric anastomosis with linear staplers, converting anterior hand-sewing suture lines of the modified Orringer technique[4] or Collard method[6] to stapling of 60-mm linear staplers (Tri-Staple 2.0 Reinforced Reload 60 mm medium/thick, the Signia powered stapler with Tri-Staple technology [Medtronic], in open or thoracoscopic surgery; SureForm60 Green Reloads [Intuitive Surgical, Inc] in robotic surgery) in both posterior and anterior walls. In order to be covered with second layers for the HLS and TLS techniques, the stapler lines were oversewn with seromuscular sutures.

STATISTICAL ANALYSES. Continuous variables are expressed as mean ± SD. Age over 70 years and body mass index less than 20 were categorized again to address old age and low body mass index, respectively. The Pearson χ^2 test, Fisher exact test, and linear-by-linear association were used for the univariate analysis of the risk factors of anastomotic stricture. Logistic regression analysis was used for the multivariate analysis. Variables with a *P* value less than .2 in the univariate analysis were included in the multivariate analysis. All variables are expressed as hazard ratios (HRs), CIs, and *P* values. Variables with *P* values less than .05 were considered to indicate statistical significance in multivariate analysis. Statistical analyses were performed using IBM SPSS ver. 19.0.

RESULTS

The demographic characteristics of the patients are summarized in Table 1. Most of the patients were male (93%) and exsmokers (63%). Current smokers were 20% of the patients. The most common location of the tumor was at the mid thoracic level (62%). Data regarding surgical procedures and postoperative complications are presented in Table 2. Cervical anastomoses were performed in 51% of patients, and thoracic anastomoses were performed in 49% of the patients. Minimally invasive esophagectomy was performed in 46% of patients. Four different types of anastomosis methods were used in the study: MS (n = 221, 30%), CS (n = 172, 23%), HLS (n = 155, 21%), and TLS (n = 189, 26%).

The univariate analysis for the risk factors of anastomotic stricture revealed that the presence of chronic obstructive pulmonary disease (COPD), liver disease, peripheral vascular disease, history of previous cancer, tumor location, open esophagectomy, anastomosis methods, leakage, and chyle leakage (chylothorax or chyloperitoneum) were statistically significant at the significance level of .2 (Tables 3 and 4). The multivariate analysis showed that the presence of COPD (HR 1.726, *P* = .017), leakage (HR 2.502, *P* = .015), and anastomosis technique other than TLS (HR 9.588 for MS, HR 6.156 for CS, HR 5.462 for HLS, all *P* < .001) were significant risk factors for stricture (Table 5). Further analysis of the anastomosis method is presented in Table 6.

The stricture rate was significantly lower in the TLS group than in the 3 other groups (22.2% in the MS group, 14.5% in the CS group, 16.1% in the HLS group, and 3.2% in the TLS group, all *P* < .001). However, there was no difference among the other 3 groups. The TLS group showed a decreased stricture rate in patients without leakage when we differentiated the stricture with and without leakage; however, in the patients with leakage, the difference disappeared when compared to the HLS group and CS group. Instead, the MS group showed a higher stricture rate in patients with leakage than the other groups. In the CS group, the effect of stapler size was assessed separately. Although there was a modest tendency, it was not statistically significant (25 mm: 19.4%, 28 mm: 13.7%, 31 mm: 10%, $P = .374$) that smaller staplers had higher stricture rates.

The leakage rate was not significantly different among the 4 anastomosis groups. Also, the leakage rate was not significantly different across the anastomosis sites (6.6% for cervical and 5.0% for intrathoracic anastomosis, HR 1.342, $P = .354$). However, the TLS group demonstrated lower leakage rate than the MS group in the situation of cervical anastomosis. (MS: HR 3.877, $P = .019$). Anastomosis site leakage significantly increased the stricture rates requiring multiple dilations (16.3% vs 4.9%, HR 3.775, $P = .007$).

The distribution of anastomosis methods differed considerably between cervical and intrathoracic anastomoses. Whereas 77.8% of TLS and 86.5% of HLS procedures were used in cervical anastomoses, 97.1% of CS techniques were used in intrathoracic anastomoses. The percentage of cervical and intrathoracic anastomoses in the MS group was similar (41.6% for cervical, 58.4% for intrathoracic anastomoses). The TLS group had a higher rate of cervical anastomosis than the CS and MS groups (CS: HR 111.111, $P < .001$; MS: HR 4.902, $P < .001$) and a lower rate of cervical anastomosis than the HLS group (HR 0.549, $P = .038$).

Although the P value in the univariate analysis was .507, additional multivariate analysis for risk factors of stricture was carried out adding the factor cervical anastomosis. This was performed in consideration of the skewed distribution of anastomosis methods and anastomosis sites. The significant variables in the multivariate analysis (COPD: HR 1.693, $P = .021$; leakage: HR 2.421, $P = .020$; and anastomosis methods other than TLS [MS: HR 10.559, $P < .001$; CS: HR 8.056, $P < .001$; HLS: HR 5.157, $P = .001$]) were unaffected by additional analysis.

The clinical courses after leakage was analyzed according to the anastomosis techniques. Esophagectomy Complications Consensus Group (ECCG) criteria were used to classify the severity of anastomosis leaks[7]; no statistically significant difference in severity was discovered between the 4 groups (TLS: 62.5%, 25.0%, 12.5% for grade I, II, III; HLS: 83.3%, 8.3%, 8.3% for grade I, II, III; CS: 63.6%, 18.2%, 18.2% for grade I, II, III; MS: 83.3%, 0.0%, 16.7% for grade I, II, III, $P = .656$). There was only 1 in-hospital morality in the TLS group with grade I leakage, on postoperative day 127 due to cancer progression. The hospital days of the patients with leakage was not significantly different between any 2 groups among the 4 groups (TLS: 76.0 ± 59.7 days, HLS: 39.5 ± 36.0 days, CS: 47.6 ± 30.3 days, MS: 41.2 ± 20.9 days, $P = .363$).

TABLE 4 Univariate Analysis II for the Risk Factors of Anastomosis Stricture

Risk Factors	Hazard Ratio	95% CI	P Value
Cervical anastomosis	1.151	0.760-1.741	.51
Minimally invasive esophagectomy	0.738	0.485-1.123	.16
Anastomosis methods			<.001
Triangular linear stapling	1		
Hybrid linear stapling	5.865	2.340-14.702	<.001
Circular stapling	5.187	2.073-12.978	<.001
Manual sewing[a]	8.689	3.630-20.800	<.001
Squamous cell carcinoma	0.851	0.346-2.093	.73
Stages			.87
I	1		
II	0.953	0.590-1.539	.84
III	0.761	0.424-1.369	.36
IV	0.734	0.311-1.730	.48
0	…	…	>.99
Postoperative leakage	3.199	1.629-6.282	<.001
Postoperative chyle leakage[b]	0.328	0.101-1.070	.05
Respiratory complication	0.940	0.480-1.840	.86
Cardiac complication	1.003	0.221-4.548	>.99
Gastrointestinal complication	1.344	0.286-6.309	.66
Urinary complication	0.666	0.083-5.309	>.99
Neurologic complication	1.178	0.638-2.175	.60
Infectious complication	1.057	0.461-2.427	.90

[a]Manual sewing includes hand sewing and robotic sewing; [b]Postoperative chyle leakage includes chyle leakage in the chest, abdomen, and neck.

COMMENT

In this study, we identified leakage, COPD, and anastomosis technique as risk factors for anastomotic

TABLE 5 Multivariate Analysis for the Risk Factors of Anastomosis Stricture

Risk Factors	Hazard Ratio	95% CI	P Value
Chronic obstructive pulmonary disease	1.726	1.104-2.699	.02
Liver disease	0.530	0.156-1.800	.31
Peripheral vascular disease	1.631	0.479-5.548	.43
Previous cancer history	1.539	0.832-2.845	.17
Tumor location			.09
Cervical	1		
Upper thoracic	5.556	0.663-46.526	.11
Mid thoracic	2.770	0.343-22.389	.34
Lower thoracic	3.068	0.369-25.534	.30
Minimally invasive esophagectomy	1.195	0.710-2.011	.50
Anastomosis methods			<.001
Triangular linear stapling	1		
Hybrid linear stapling	5.462	2.141-13.935	<.001
Circular stapling	6.516	2.357-18.018	<.001
Manual sewing[a]	9.588	3.796-24.220	<.001
Postoperative leakage	2.502	1.195-5.236	.02
Postoperative chyle leakage[b]	0.486	0.143-1.656	.25

[a]Manual sewing includes hand sewing and robotic sewing; [b]Postoperative chyle leakage includes chyle leakage in the chest, abdomen, and neck.

TABLE 6 Anastomosis Leakage and Stricture Rate According to the Anastomosis Methods

	TLS	HLS	CS	MS	P Value
Leakage (total)	8 (4.2)	12 (7.7)	11 (6.4)	12 (5.4)	.56
Cervical anastomosis	4 (2.7)	11 (8.2)	1 (20.0)	9 (9.8)	.04[a]
Intrathoracic anastomosis	4 (9.5)	1 (4.8)	10 (6.0)	3 (2.3)	.17
Stricture (total)	6 (3.2)	25 (16.1)	25 (14.5)	49 (22.2)	<.001[b]
Stricture without leakage	5 (2.8)	22 (15.4)	23 (14.3)	41 (19.6)	<.001[c]
Stricture with leakage	1 (12.5)	3 (25.0)	2 (18.2)	8 (66.7)	.04[d]

[a]Among cervical anastomoses, leakage rate was significantly lower in the TLS group than the MS group (MS: HR 3.877; $P = .019$). However, there was no difference among other groups; [b]Total stricture rate was significantly lower in the TLS group than the 3 other groups (HLS: HR 5.865, CS: HR 5.187, MS: HR 8.689; all $P < .001$). There was no difference among the 3 other groups; [c]Stricture rate without leakage was significantly lower in the TLS group than the 3 other groups (HLS: HR 6.400, CS: HR 5.867, MS: HR 8.590; all $P < .001$). There was no difference among the 3 other groups; [d]In the TLS group, stricture rate with leakage was not significantly different with HLS or CS groups (HLS: HR 2.331, $P = .619$; CS: HR 1.555; $P = 1.000$). Stricture rate with leakage was significantly higher in the MS group than the 3 other groups (TLS: HR 0.071, $P = .028$; HLS: HR 0.167, $P = .041$; CS: HR 0.111, $P = .036$). Values are presented as n (%). CS, circular stapling; HLS, hybrid linear stapling with a 45-mm length stapler; MS, manual sewing; TLS, triangular linear stapling with 60-mm length staplers.

stricture after esophagectomy using multivariable analysis. Among the 4 different anastomosis techniques, TLS could make the largest anastomosis area and show the lowest anastomosis stricture rate. The difference was significant, especially in patients who did not experience leakage. However, in patients with leakage, the preventive effect could not be reproduced. This suggests that leakage is a more potent risk factor for the development of strictures than the anastomosis technique.

Leakage and COPD have been documented as risk factors for anastomotic stricture in many studies.[2,8-14] Leakage is one of the most potent risk factors for strictures. This interrelation can be attributed to the fact that postoperative leakage and stricture are commonly influenced by the healing process associated with the oxygenation and perfusion status of the anastomosis tissue.[5] Another hypothesis is that the irritative effect of leaked material can cause an inflammatory response and cause excessive scar formation, which can be inferred from the effectiveness of steroid injection in benign esophageal strictures.[15] The leakage rate was not influenced by the different anastomosis techniques as proven in other previous studies.[16-18] In our study, the presence of COPD was a significant risk factor for stricture after esophagectomy. This was previously reported by Hosoi and associates.[8] Another study also reported that low preoperative partial pressure of arterial oxygen is a risk factor for stricture.[9] COPD or low oxygen saturation can be understood as a risk factor for stricture because it jeopardizes adequate tissue oxygenation and healing.

In this study, we focused on the differences between the anastomosis techniques. We classified the anastomosis techniques into 4 categories according to the methods and devices used to include all possible types of anastomoses. The TLS used in this study has several advantages compared with the other methods. By using 60-mm staplers, we could make the largest anastomosis area compared with any other technique.[19] Theoretically, we could make a two-times-larger anastomosis area in TLS. Another advantage is that it can stretch the anastomosis line during stapling. This is a big difference from the continuous suturing technique, which induces a purse-string effect and reduces the anastomosis area. These 2 technical features have the potential to prevent strictures.[20]

Many retrospective studies comparing the stricture rate between TLS and other anastomosis techniques have been reported.[11-13,21-27] Most studies compared only 2 different types of anastomosis techniques. According to those studies, TLS demonstrated a lower stricture rate compared to MS,[11,12,26,27] CS,[22-25] and HLS.[13,21] However, a randomized controlled study comparing TLS and CS has recently been published. Hosoi and coworkers[28] reported that TLS showed better outcomes in terms of stricture rate and quality of life. In that study, the authors included 50 patients in each study arm and compared the stricture rates. They reported a 0% stricture rate in the TLS group and a 42% stricture rate in the CS group. Our results in this study are similar to those of previous studies. TLS showed a 3% stricture rate when leakage was absent, and the stricture rate was significantly lower than that of other techniques.

The cross-sectional area (CSA) of the anastomosis site can be theoretically calculated assuming that the diameter of the normal esophagus is 30 mm. The end-to-end hand-sewing CSA cannot exceed 706.5 mm^2, as the area of the circle is calculated by $\pi \times \left(\frac{diameter}{2}\right)^2$ (Figure 1A). Circular staplers with a diameter of 28 mm or 31 mm[8,29] will produce 615.4 or 754.4 mm^2 CSA (Figure 1B). The suture lines of the anterior wall of the hybrid linear stapling method cannot make the base of an isosceles triangle longer than 30 mm unless further excision of the conduit is performed. The CSA of the hybrid linear stapling method was approximately $636.4 + \alpha$ mm^2 (Figure 1C). Using the triangular stapling method with 60-mm length linear staplers, we created an equilateral triangle with a CSA of 1558.8 mm^2 (Figure 1D). There was no obstacle in utilizing full length of 60-mm linear staplers for anterior wall anastomosis, because the length is limited to the circumference of the esophagus, which is much longer than 60 mm. As stapling enables even distribution, straightening, and fixation of the anterior suture layer tissue, reproducible results can be obtained with minimal interference from the surgeon's skills.

The benefit of linear stapling for strictures is more distinct in patients without leakage. We suspect that this finding is due to the direct causal relationship of the anastomosis area, excluding the effect of leakage.[5,30] As proven in many previous reports and in our study, leakage itself is the most potent risk factor for stricture in esophagectomy patients. In addition, the effect of a larger anastomosis area by TLS could not be reproduced in case of leakage. This can be explained by the overgrowth of healing tissue in the anastomosis, which can decrease the luminal area significantly, regardless of the size of the area was made initially.

This is one of the largest studies on anastomosis strictures, comparing different anastomosis techniques. However, this study had several limitations. First, the data were derived from 5 surgeons over 17 years. The second limitation was the retrospective nature of the study. Although we could identify the difference in the multivariable analysis in our study, any hidden bias might have affected the outcomes of the study. However, a recently published randomized controlled study[28] reported the same result as our study and supports the conclusion of our study.

In this study, we identified 3 risk factors for anastomotic stricture: leakage, COPD, and anastomosis technique. The triangular linear stapling technique could offer the largest anastomosis area and had a preventive role for anastomosis stricture, especially when leakage was not present. Triangular linear stapling can be considered a valuable esophagogastric anastomosis method in esophageal cancer surgery.

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Esophageal Anastomoses: Bigger Is Still Usually Better

INVITED COMMENTARY:

In this issue of *The Annals of Thoracic Surgery*, Na and colleagues[1] present a retrospective, single-institution review of 737 patients undergoing esophagectomy and correlate anastomotic technique with leak and stricture requiring dilation. Intrathoracic and cervical anastomotic locations, along with hand sewn, circular stapled (CS), hybrid 45-mm linear stapled with anterior wall suture closure (HLS), and triangular 60-mm linear stapled anterior and posterior wall (TLS) techniques were included. There was no difference in leak rate. Multivariate analysis showed anastomotic technique, chronic obstructive pulmonary disease, and leak to be associated with stricture. The TLS technique showed significantly less stricturing in patients without a leak.

The results parallel previous studies showed a reduced stricture rate with linear anastomoses, including a recent randomized controlled trial demonstrating decreased stricture and improved quality of life with a modified Collard compared with the CS method in patients with cervical anastomoses.[2] The TLS technique may offer additional advantages by alleviating the need to force a large-diameter end-to-end anastomosis (EEA) stapler between the ribs or an EEA anvil into the esophagus, potentially decreasing postoperative pain and technical difficulty in smaller patients. Finally, with the increasing popularity of robotic esophagectomy, the TLS technique allows the operation to be completed from the console, obviating the need for a skilled assistant at the bedside to pass the EEA stapler.

However, it may be premature for thoracic surgeons to completely discard the EEA stapler from their armamentarium. Completion of the 60-mm TLS anastomosis requires long segments of esophagus and stomach, which may not be available during Ivor Lewis esophagectomy, when the esophagus must be divided proximally, or if perfusion to the gastric conduit appears compromised. In the event of an intrathoracic leak, the geometry and large size of the TLS anastomosis may make stenting and subsequent management difficult.

The authors attempt to address this by examining hospital stay in patients with leaks and show no significant difference between anastomotic methods. However, there did appear to be a trend toward a longer length of stay in the TLS group (76 days vs 39.5-41.2 days for the other groups). Because cervical leaks are managed with opening of the neck incision and often only a slightly delayed discharge, it is possible the intrathoracic leaks disproportionately contributed to the long length of stay in the TLS leak cohort.

Given that most patients with anastomotic strictures only require 1 or 2 dilations,[3] balancing a reduction in the need for outpatient dilation (14.5% CS vs 3.2% TLS) with a potential increased length of stay in patients who do leak is a difficult value proposition. Ultimately, the individual surgeon will have to determine which anastomotic approach they are most comfortable with, but the results here are favorable for the TLS technique, particularly in cervical anastomoses.

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