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RESEARCH

Analysis of surgical outcomes and risk factors for anastomotic leakage following trans-hiatal resection of esophagogastric junction cancer

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Abstract

Background The trans-hiatal lower esophagectomy is considered less invasive than the trans-thoracic esophagectomy for resection of esophagogastric junction (EGJ) cancer. However, the optimal procedure remains controversial and should be determined while considering both oncological and safety aspects.

Methods This retrospective study comprised 124 patients that underwent curative resection for EGJ cancer. The study analysis included 93 patients with tumor centers located within 2 cm of the EGJ. Clinicopathological findings and surgical outcomes were compared between patients treated using trans-hiatal and trans-thoracic approaches.

Results Sixty-three patients underwent lower esophagectomy using the trans-hiatal approach (TH-G). The remaining 30 patients underwent esophagectomy using the trans-thoracic approach (TT-E). The TH-G group were older, had a lower prevalence of lymphatic spread, shorter length of esophageal invasion, and shorter operative duration compared to the TT-E group. Although no significant differences in the frequency of postoperative complications, a higher proportion of patients in the *TH-G* group developed anastomotic leakage (16% vs. 7%, $p = 0.33$). Univariate and multivariate analyses demonstrated that cardiac comorbidity was an independent risk factor for anastomotic leakage (odds ratio, 5.24; 95% CI, 1.06–25.9; $P < 0.05$) in TH-G group. Further examination revealed that preoperative cardiothoracic ratio (CTR) with 50% or greater could be surrogate marker as risk factor for anastomotic leakage in TH-G group (35% vs. 7.5%, $p < 0.05$).

Conclusions The trans-hiatal approach can be used for resection of EGJ cancer. However, special attention should be paid to the prevention of anastomotic leakage in patients with cardiac comorbidities or a large preoperative CTR.

Keywords Esophagogastric junction cancer · Trans-hiatal lower esophagectomy · Trans-thoracic esophagectomy · Anastomotic leakage · Postoperative complication

Introduction

The incidence of gastric cancer remains high worldwide despite the implementation of prophylactic eradication of Helicobacter pylori in some East Asian countries. The prevalence of upper gastric cancer, particularly esophagogastric junction (EGJ) cancer, has been increasing in Eastern Asia and Western countries [1, 2]. The anatomical features of the EGJ promote local invasion into surrounding tissues and lymph node metastasis and contribute to the poor surgical outcomes and prognosis of EGJ cancer.

A recent Japanese prospective multicentric study examined the incidence of metastasis to each lymph node in patients with EGJ cancer and proposed an algorithm for the dissection of lymph nodes with a 10% of greater risk of metastasis according to the length of esophageal involvement [3]. The trans-hiatal approach for lower esophagectomy with total or proximal gastrectomy and the trans-thoracic approach for esophagectomy with proximal gastrectomy have previously been used for the resection of EGJ cancer. The trans-hiatal approach is considered less invasive than the trans-thoracic approach; however, the narrow and restricted surgical field appears to contribute to an increased incidence of anastomosis-related complications. In recent years, postoperative complications have been reported to be

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correlated with short-term outcomes in addition to long-term oncological outcomes [4–7]. Accordingly, there is a need to determine the optimal approach for the resection of EGJ cancer while considering both oncological and safety aspects.

In the present study, we retrospectively reviewed clinicopathological factors and surgical outcomes in patients with EGJ caner treated at our hospital to identify risk factors for anastomotic leakage following use of the trans-hiatal approach to EGJ cancer resection.

Material and methods

Patients and outcomes

A total of 124 patients underwent curative surgical resection for EGJ cancer at our institution from June 2004 to April 2022. Of these, 93 patients with tumors with a center located within 2 cm of the esophagogastric junction based on examination of resected specimens were enrolled in the present retrospective study. In general, patients were preoperatively evaluated using endoscopic and fluoroscopic examinations and underwent chest radiography and abdominal computed tomography (CT) to evaluate disease progression. All tumors were preoperatively diagnosed as cancer according to the results of pathological examinations. Clinical and pathological findings were staged according to the current Japanese Classification of Gastric Cancer [8]. The surgical strategy was determined by each surgeon with the estimated length of esophageal invasion the main consideration. The trans-thoracic approach was the principal approach used in cases with intra-thoracic lymphadenopathy. Regarding individual anastomosis methods, a circular stapler was used in all cases with the trans-thoracic approach, regardless of whether it was a cervical or intra-thoracic anastomosis. Alternatively, circular staplers, linear staplers, and hand suture anastomoses were chosen by the surgeon for the trans-hiatal approach.

Clinicopathological data were obtained from retrospective review of hospital records. Collected data included patient age, gender, body mass index (BMI), the American Society of Anesthesiologist (ASA) physical status classification (ASA-PS), comorbidity (heart disease, lung disease, renal disease, diabetes mellitus), tumor characteristics (tumor size, length of esophageal invasion), operative method (open or laparoscopic; trans-hiatal or trans-thoracic approach), operative duration, intraoperative blood loss, postoperative complications (anastomotic leakage, surgical site infection, pneumonia, and recurrent nerve paralysis), length of hospital stay, receipt of perioperative chemotherapy, tumor pathology, lymph node staging, and pattern of recurrence. Clinicopathological findings and surgical outcomes were compared between each surgical procedure. Furthermore, to make the patient backgrounds of the two groups as homogeneous as possible, we also performed propensity score matching analyses. Risk factors for anastomotic leakage following use of the trans-hiatal approach were also investigated.

Statistical analyses

Statistical analyses were performed using R (version2.7-0: Sun Nov 6 19:40:57 2022). Chi-square tests or Fisher's exact tests and the Mann-Whitney *U* test were used for comparisons as appropriate. Prognostic analyses were performed using Kaplan–Meier method, and the differences were evaluated by the log-rank test. Propensity scores of patient characteristics were generated using binary logistic regression models. Univariate and multivariate analysis were performed using Cox regression models to identify the risk factors for anastomotic leakage. A p-value of <0.05 was considered statistically significant.

Results

Patient population and tumor characteristics

Of the 93 patients included in the study analysis, 63 patients underwent lower esophagectomy with proximal or total gastrectomy using the trans-hiatal approach (TH-G). The remaining 30 patients underwent esophagectomy using the trans-thoracic approach (TT-E). Patient characteristics according to surgical procedure are summarized in Table 1. Patients were significantly older in the TH-G group (median, 73 years; range, 37–86 years) compared to the TT-E group (median, 65 years; range, 41–84 years; $p < 0.05$). A higher proportion of patients had no lymphatic spread (N1 or less) in the TH-G group (81%) compared to the TT-E group (60%; $p < 0.05$). Moreover, the length of esophageal invasion was significantly shorter in the TH-G group (median, 15 mm; range, 0–35 mm) compared to the TT-E group (median, 31 mm; range, 10–100 mm; $p < 0.05$). However, no significant differences in sex, BMI, ASA-PS, comorbidity, macroscopic tumor appearance, tumor histology, or tumor depth were observed between the TH-G and TT-E groups.

Surgical outcomes

Operative duration was significantly longer in the TT-E group (median, 574 min; range, 380–1840 min) compared to the TH-G group (median, 390 min; range, 207–807 min; $p < 0.05$). No significant difference in intraoperative blood loss was observed between the two groups. No significant differences in the incidence of postoperative complications (Clavien–Dindo classification $\geq$ grade 3) or length of hospital stay were observed between the TH-G and TT-E groups. Recurrent nerve paralysis was observed in the TT-E

Table 1 Patient characteristics

Variables	Before PSM			After PSM			SMD (Before/After)
	TH-G group (*n*=63)	TT-E group (*n*=30)	*p*-value	TH-G group (*n*=15)	TT-E group (*n*=15)	*p*-value	
Age(years), median(range)	73 (37−86)	65 (41−84)	< 0.05*	67 (37−82)	65 (52−80)	0.77*	0.57 / 0.06
Sex(male)	49 (77.8%)	24 (80%)	1†	14 (93.3%)	13 (86.7%)	1†	
BMI, median(range)	23 (16−36)	24 (17−32)	0.55*	24.09 (18.2−31.3)	23.71 (16.6−31.7)	0.91*	
ASA-PS			0.36†			0.6†	
1,2	55 (87.3%)	24 (80%)		14 (93.3%)	12 (80%)		
3 ≦	8 (12.7%)	6 (20%)		1 (6.7%)	3 (20%)		
Comorbidities							
Cardiac	19 (30.2%)	4 (13.3%)	0.12†	7 (46.7%)	3 (20%)	0.25†	
Diabetes	24 (38.1%)	8 (26.7%)	0.35†	9 (60%)	5 (33.3%)	0.27†	
Renal	11 (17.5%)	3 (10%)	0.54†	5 (33.3%)	2 (13.3%)	0.39†	
Pulmonary	10 (15.9%)	7 (23.3%)	0.4†	2 (13.3%)	2 (13.3%)	1†	
Tumor type			0.5†			0.72†	
Localized	22 (34.9%)	13 (43.3%)		7 (46.7%)	9 (60%)		
Diffuse	41 (65.1%)	17 (56.7%)		8 (53.3%)	6 (40%)		
Pathological type			0.28†			0.48†	
Adenocarcinoma	58 (92.1%)	25 (83.3%)		15 (100%)	13 (86.7%)		
Squamous cell carcinoma	5 (7.9%)	5 (16.7%)		0 (0%)	2 (13.3%)		
Pathological depth			0.81†			0.68†	0.11 / 0.31
pT1	22 (34.9%)	9 (30%)		3 (20%)	5 (33.3%)		
pT2-4	41 (65.1%)	21 (60%)		12 (80%)	10 (66.7%)		
Lymph node metastases			< 0.05†			1†	0.514 / < 0.01
pN0,pN1	52 (82.5%)	18 (60%)		9 (60%)	9 (60%)		
pN2 ≦	11 (17.5%)	12 (40%)		6 (40%)	6 (40%)		
Tumor size(mm), median(range)	45 (12−110)	47.5 (10−120)	0.52*	48 (25−95)	35 (10−85)	0.17*	
Esophageal invasion(mm), median(range)	15 (0−35)	31 (10−100)	< 0.05*	25 (10−35)	25 (10−35)	0.93*	1.38 / 0.05

Statistical method: Mann-Whitney U test: *, Fisher's exact test:† Abbreviations: *PSM*, propensity score matching; *TH-G*, trans-hiatal lower esophagectomy with total/proximal gastrectomy; *TT-E*, trans-thoracic esophagectomy; *BMI*, body mass index; *ASA-PS*, American Society of Anesthesiologists-physical status

group only (Table 2). Survival analyses demonstrated similar survival following both procedures (Fig. 1-A). Three of the 93 patients developed intra-thoracic lymphatic recurrence during the follow-up period, of which only one patient had apparent solitary intra-thoracic lymphatic metastasis as the first evidence of disease recurrence.

Propensity score-matched analysis

We generated propensity scores for patient characteristics that differed between the two groups (age, pathological tumor depth, number of lymph node metastases, and length of esophageal invasion), and 30 cases with matched scores were selected. In this new patient group, there were no significant differences in patient background between the two different surgical approaches (Table 1). In the analysis of surgical outcomes, although there were differences in the surgery duration (TH-G group: median, 401 min; range, 214–783 min vs. TT-E group: median, 543 min; range, 380–1840 min, $p < 0.05$) and organs for substitution, none of the other variables differed significantly between the two groups (Table 2). Kaplan–Meier curves were created and compared for prognosis; however, the trans-thoracic approach, with its superior lymph node dissection did not show a better outcome. Comparatively, the curve was below that of the trans-hiatal approach (Fig. 1-B).

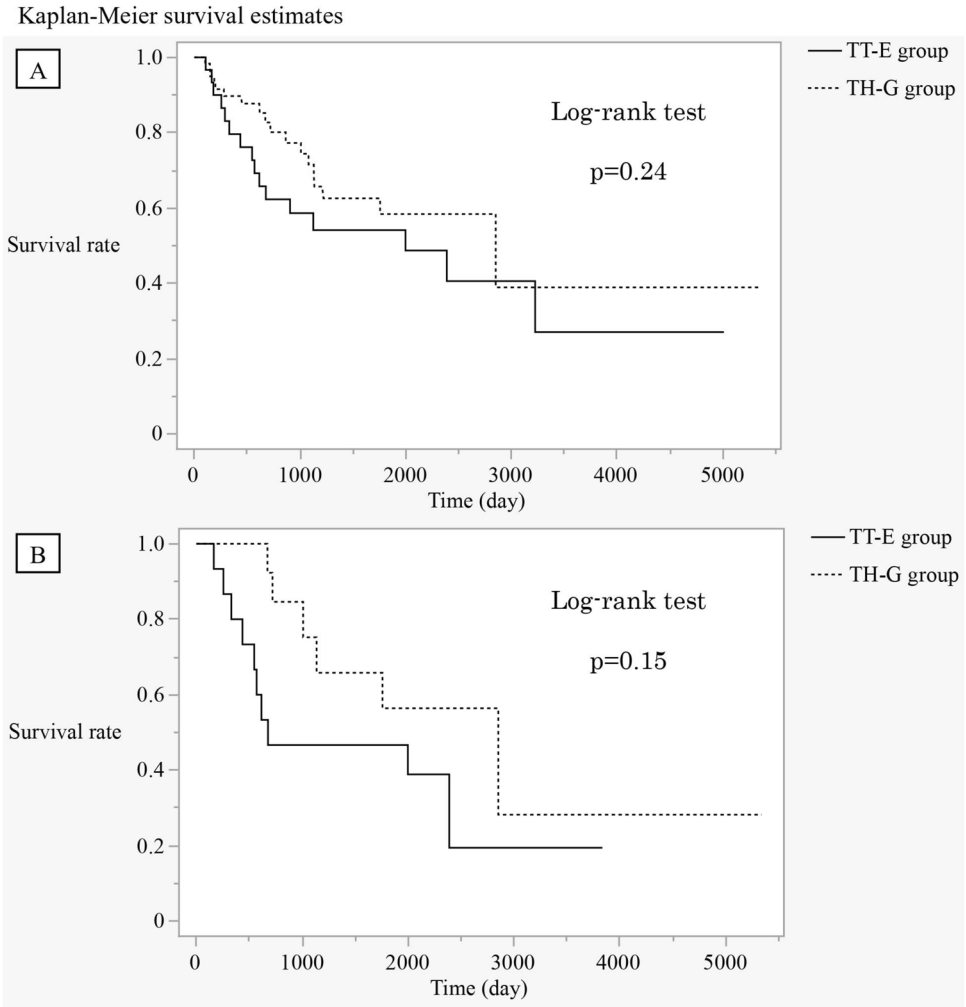


Fig. 1 **A** Before propensity score matching. **B** After propensity score matching

A: Before propensity score matching./ B: After propensity score matching.
Abbreviations: TH-G, trans-hiatal lower esophagectomy with total/proximal gastrectomy; TT-E, trans-thoracic esophagectomy

Identification of risk factors for anastomotic leakage following use of the trans-hiatal approach

Among several complications, anastomotic leakage was the most frequent in this cohort, and the tendency was more noticeable in TH-G group (Table 2). Therefore, we examined the correlation analyses between the frequency and various clinicopathological factors. As a result, several factors, such as poor performance status (OR:4.03, 95%CI:0.78–20.7, $p = 0.09$), heart disease (OR:7.97, 95%CI:1.78–35.6, $p < 0.05$), excessive blood loss (OR:4.94, 95%CI:1.14–21.5, $p < 0.05$) were selected as risk factors for anastomotic leakage by univariate analysis. Subsequent multivariate analysis clearly demonstrated that only presence of comorbid cardiac disease was an independent risk factor for anastomotic leakage (OR:5.24, 95%CI:1.06–25.9, $p < 0.05$) (Table 3). Further examination for the useful surrogate clinical risk factors demonstrated that preoperative cardiothoracic ratio (CTR) was significantly correlated with incidence of anastomotic leakage (Fig. 2), and patients with 50% or more CTR developed significantly more frequently anastomotic leakage than those with less CTR (35% vs. 7.5%, $p < 0.05$) (Table 4).

Discussion

The optimal procedure for the resection of EGJ cancer remains controversial. Previous studies have demonstrated that patients with EGJ cancer, particularly Siewert type I tumors, treated with trans-thoracic subtotal esophagectomy with mediastinal lymph node dissection have superior prognosis [9]. Recent studies have clearly demonstrated that patients treated with lower esophagectomy and proximal or total gastrectomy with regional lymph node dissection using the trans-hiatal approach have superior short-term outcomes and equivalent prognosis to

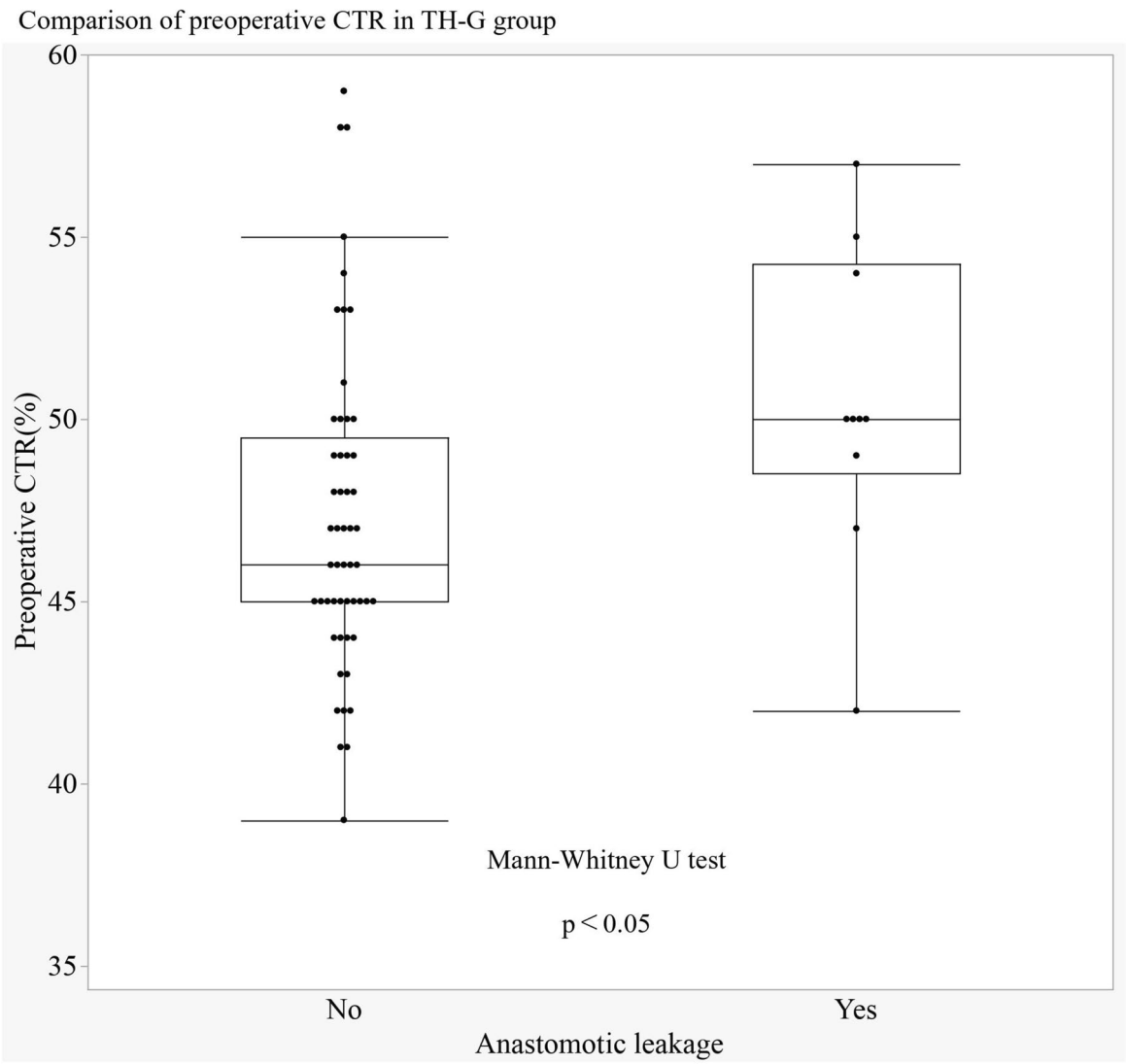
Table 2 Surgical outcomes

Variables	Before PSM			After PSM		
	TH-G group (*n*=63)	TT-E group (*n*=30)	p-value	TH-G group (*n*=15)	TT-E group (*n*=15)	*p*-value
Approach			0.38†			1†
Open	33 (52.4%)	19 (63.3%)		12 (80%)	11 (73.3%)	
Laparoscopic/Thoracoscopic	30 (47.6%)	11 (36.7%)		3 (20%)	4 (26.7%)	
Operative time(min), median(range)	390 (207−807)	574 (380−1840)	< 0.05*	401 (214−783)	543 (380−1840)	< 0.05*
Blood loss(ml), median(range)	324 (5−2299)	581 (39−3257)	0.06*	725 (11−2299)	474 (39−3257)	0.2*
Intraoperative transfusion	11 (17.5%)	8 (26.7%)	0.41†	4 (26.7%)	4 (26.7%)	1†
Number of LN dissection, median(range)	31 (3−77)	38.5 (10−173)	< 0.05*	29 (6−77)	40 (12−77)	0.09*
Anastomotic method			< 0.05†			1†
Circular stapler	50 (79.4%)	30 (100%)		100 (100%)	100 (100%)	
Linear stapler	8 (12.7%)	0 (0%)		0 (0%)	0 (0%)	
Hand sewn	5 (7.9%)	0 (0%)		0 (0%)	0 (0%)	
Organ for substitution (Stomach/Jejunum/Colon)			< 0.05†			< 0.05†
Stomach	6 (9.5%)	24 (80%)		1 (6.7%)	10 (66.7%)	
Jejunum	57 (90.5%)	5 (16.7%)		14 (93.3%)	4 (26.7%)	
Colon	0 (0%)	1 (3.3%)		0 (0%)	1 (6.7%)	
Hospital stay(days), median(range)	17 (9−141)	21 (12−75)	0.17*	26 (10−121)	21 (12−61)	0.14*
Post operative complications						
Pneumonia	4 (6.3%)	3 (10%)	0.68†	0 (0%)	1 (6.7%)	1†
Anastomotic leakage	10 (15.9%)	2 (6.7%)	0.33†	3 (20%)	2 (13.3%)	1†
Surgical site infection	4 (6.3%)	1 (3%)	0.91†	1 (6.7%)	1 (6.7%)	1†
Recurrent nerve paralysis	0 (0%)	3 (10%)	< 0.05†	0 (0%)	1 (6.7%)	1†
CD Grade3 ≦ complications	12 (19%)	5 (16.7%)	1†	4 (26.7%)	5 (33.3%)	1†

Statistical method: Mann-Whitney U test: *, Fisher's exact test:†. Abbreviations: *PSM*, propensity score matching; *TH-G*, trans-hiatal lower esophagectomy with total/proximal gastrectomy; *TT-E*, trans-thoracic esophagectomy; *LN*, lymph node; *CD*, Clavien-Dindo classification

patients treated with trans-thoracic esophagectomy, which is considered highly invasive. Several meta-analyses have reported that the trans-hiatal approach, which is considered less invasive, is associated with shorter operative duration, lower intraoperative blood loss, shorter hospital stay, and lower in-hospital mortality compared to the trans-thoracic approach [10–12]. However, other studies have reported no difference in long-term outcomes between the two approaches [13–15]. Among patients treated using the trans-hiatal approach in the present study, only one patient developed disease recurrence in the mediastinal region, which may have been removed if treated using the trans-thoracic approach. However, the therapeutic efficacy of the trans-thoracic approach in treating disease in the mediastinal region remains uncertain. These findings indicate the trans-hiatal approach is a reasonable surgical option for the resection of EGJ cancer, which is consistent the results of the present study. In this study, there was no difference in prognostic analysis between the two groups for the trans-thoracic and trans-hiatal approaches, and the results were similar even when propensity score matching was used to homogenize the clinicopathologic factors. Preferably, the fact that the survival curve was below in the trans-thoracic approach group with a higher degree of lymph node dissection may indicate the magnitude of the surgical invasion or the limitations of the therapeutic effect of the trans-thoracic farther dissection of lymph nodes.

The safety and efficacy of minimal invasive surgery is extremely important in clinical practice as postoperative complications can reduce long-term quality of life. In the present study, anastomotic leakage was the most frequent complication, particularly in the TH-G group. Norero et al. reported that tumor localization at the EGJ is an independent risk factor for anastomotic leakage following gastrectomy for gastric cancer [16]. These findings may indicate that shortening of the esophagus leads to more complicated reconstructive procedures in cases of EGJ cancer than non-EGJ cancer. In fact, various reconstructive methods have developed for safe and definitive anastomosis using the trans-hiatal approach. Several factors in addition to the shortened esophagus, such as the narrow anatomical space and the mobility of the remnant stomach or jejunum,



Abbreviations: CTR, Cardio Thoracic Ratio, which is measured on a PA chest x-ray, and is the ratio of maximal horizontal cardiac diameter to maximal horizontal thoracic diameter (Inner edge of ribs / edge of pleura).

Fig. 2 Comparison of preoperative CTR in TH-G group

may contribute to the technical difficulty of anastomosis formation. Furthermore, formation of a robust anastomosis is more challenging in obese patients or patients with a hiatal hernia [17].

There are limited reports on the risk factors for postoperative anastomotic leakage in patients with EGJ cancer. Mine et al. reported that only large tumor size was significantly associated with anastomotic leakage following use of the trans-hiatal approach, with correlation observed between clinical demographics and the incidence of anastomotic leakage in a prospective clinical trial [18], However, patients with relatively good general condition tend to be enrolled in prospective clinical studies and various other factors may affect study results in clinical practice. In the present study, we aimed to identify risk factors for anastomotic leakage following resection of EGJ cancer using the trans-hiatal approach and identified history of cardiac disease as an independent risk factor for anastomotic leakage. The cardiac volume occupies a large portion of the lower mediastinum, with cardiac enlargement expected to protrude into the posterior lower mediastinum and subsequently obstruct the operative field. These findings may indicate that a clear surgical view of the anastomosis is important for the formation of a robust anastomosis using the trans-hiatal approach for resection of EGJ cancer compared to resection of common gastric cancers. Additionally, several previous

Table 3 Risk factors for anastomotic leakage in TH-G group (*n*=63)

Variables	Univariate logistic regression			Multivariate logistic regression		
	OR	95%CI	*p*-value	OR	95%CI	*p*-value
Age > 70	1.53	0.36−6.6	0.57			
ASA-PS ≧ 3	4.03	0.78−20.7	0.09	1.83	0.28−12.1	0.53
BMI > 25	1.71	0.42−7.01	0.45			
Comorbidities						
Cardiac	7.97	1.78−35.6	< 0.05	5.24	1.06−25.9	< 0.05
Diabetes	1.79	0.46−6.98	0.4			
Renal	2.41	0.51−11.3	0.27			
Pulmonary	1.41	0.25−7.87	0.7			
Laparoscopic surgery	0.41	0.096−1.77	0.23			
Anastomotic method (Stapler)	0.94	0.1−9	0.96			
Organ for substitution (Stomach)	1.07	0.11−10.2	0.96			
Blood loss > 500ml	4.94	1.14−21.5	< 0.05	3.31	0.67−16.3	0.14
Operation time > 480min	0.91	0.21−3.95	0.9			
Clinical tumor depth > T2	1.73	0.33−9.1	0.52			
Tumor size > 45mm	0.6	0.15−2.35	0.46			
Esophageal invasion > 20mm	1.54	0.38−6.22	0.54			
Esophageal invasion > 30mm	1.07	0.11−10.2	0.96			

Statistical method: logistic regression analysis. Abbreviations: *TH-G*, trans-hiatal lower esophagectomy with total/proximal gastrectomy; *OR*, odds ratio; *95% CI*, 95% confidence interval; *ASA-PS*, American Society of Anesthesiologists-physical status; *BMI*, body mass index

Table 4 Surgical outcomes focused on Preoperative CTR in TH-G group

Variables	Preoperative CTR ≧ 50% (*n*=20)	Preoperative CTR < 50% (*n*=43)	*p*-value
Approach			< 0.05†
Open	15 (75%)	18 (41.9%)	
Laparoscopic	5 (25%)	25 (58.1%)	
Operative time(min), median (range)	336 (207−807)	421 (225−783)	< 0.05*
Blood loss(ml), median (range)	509 (5−2299)	260 (8−1488)	0.15*
Hospital stays(day), median (range)	29 (10−141)	14 (9−89)	< 0.05*
Post operative complications			
Pneumonia	2 (10%)	2 (4.7%)	0.59†
Anastomotic leakage	7 (35%)	3 (7%)	< 0.05†
Surgical site infection	1 (5%)	3 (7%)	0.91†
≧ CD Grade3 complications	7 (35%)	5 (11.6%)	< 0.05†

Statistical method: Mann-Whitney U test:*, Fisher's exact test:†. Abbreviations: *CTR*, Cardio Thoracic Ratio; *CD*, Clavien-Dindo classification

reports suggest that venous congestion can impair tissue blood perfusion and contribute to anastomotic complications [19–21]. In patients with heart failure, systemic venous perfusion might be impaired due to the stagnation of blood circulation associated with a decreased cardiac output. Therefore, similar perfusion impairments may occur at local anastomoses, leading to impaired blood flow and anastomotic troubles.

We further evaluated CTR as a surrogate marker of cardiac status and examined the association between preoperative CTR and anastomotic leakage in TH-G group. We found that the incidence of anastomotic leakage was significantly higher in patients with a preoperative cardiothoracic ratio (CTR) of 50% or greater, which supported our hypothesis. The surgical view of the mediastinal space may be impaired in obese patients or patients with a hiatal hernia; however, we observed no correlation between such factors and the incidence of anastomotic leakage in the present study. These findings indicate that obscurement of the surgical field by the cardiac volume is critical when using the trans-hiatal

approach for the resection of EGJ cancer. In addition, we only analyzed surgical outcomes in the cardiac high-risk cohort (preoperative CTR ≥50 or with cardiac comorbidity, n = 36; data not shown); however, there was no clear evidence of a preferable approach in the cardiac high-risk group. Even in the cardiac high-risk cohort, the frequency of anastomotic leakage is higher with the trans-hiatal approach (the difference was not significant). Hence, the trans-thoracic approach might be a preferable option for patients with large preoperative CTR if they can tolerate the surgical procedures.

These findings highlight the importance of developing a preoperative and intraoperative fluid management plan for patients with esophagogastric junction (EGJ) cancer and cardiac disease, particularly in cases with a high CTR. In fact, we occasionally experience gradual obscurement of the mediastinal surgical field as operations progress. In recent years, robotic-assisted surgery has become an alternative option, with some studies reporting the utility of robotic-assisted surgery for EGJ cancer and performing comparisons with conventional surgery [22–24]. Robotic surgery provides a stable field of view with no obscurement of surgical instruments or cameras. In addition, stable suture manipulation can be performed even with a narrow surgical field of view as the robotic arm has joints. These novel medical technologies may lead to a decreased incidence of anastomotic leakage in these challenging cases.

Regarding the limitations of the present study, this was a retrospective study using data from medical records and a limited number of cases from only one center. Accordingly, future prospective studies or further accumulation of cases are required to validate our findings. In addition, measurement of the CTR on preoperative radiography is an objective, simple, and generic method; however, further studies using more detailed imaging techniques such as CT or echocardiography, or a serological heart failure marker, such as brain natriuretic peptide are required to more robustly determine the relationship between cardiac disease and anastomotic leakage following use of the trans-hiatal approach for resection of EGJ cancer.

Conclusion The trans-hiatal approach is an appropriate method of resecting EGJ cancer in patients with a relatively short segment of esophageal involvement; however, special attention should be paid to preventing anastomotic leakage in patients with cardiac comorbidities. A large preoperative CTR may be a surrogate marker of cardiac disease and have utility in identifying patients at increased risk of anastomotic leakage following use of the trans-hiatal approach for the resection of EGJ cancer.

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Declarations

Conflict of interest The authors declare no competing interests.

References

1. Sekiguchi M, Oda I, Matsuda T et al (2022) Epidemiological trends and future perspectives of gastric cancer in Eastern Asia. Digestion 103(1):22–28
2. Prashanth R, Adam B (2019) Epidemiology of gastric cancer: global trends, risk factors and prevention. Gastroenterol Rev 14(1):26–38
3. Kurokawa Y, Takeuchi H, Doki Y et al (2021) Mapping of lymph node metastasis from esophagogastric junction tumors: A prospective nationwide multicenter study. Ann Surg 274(1):120–127
4. Kubota T, Hiki N, Sano T et al (2014) Prognostic significance of complications after curative surgery for gastric cancer. Ann Surg Oncol 21(3):891–898
5. Li SS, Udelsman BV, Parikh A et al (2020) Impact of postoperative complication and completion of multimodality therapy on survival in patients undergoing gastrectomy for advanced gastric cancer. J Am Coll Surg 230(6):912–924
6. Kataoka K, Takeuchi H, Mizusawa J et al (2017) Prognostic impact of postoperative morbidity after esophagectomy for esophageal cancer: Exploratory analysis of JCOG9907. Ann Surg 265(6):1152–1157
7. Baba Y, Yoshida N, Shigaki H et al (2016) Prognostic impact of postoperative complications in 502 patients with surgically resected esophageal squamous cell carcinoma: A retrospective single-institution study. Ann Surg 264(2):305–311
8. Katai H, Ishikawa T, Akazawa K, Isobe Y, Miyashiro I, Oda I Registration Committee of the Japanese Gastric Cancer Association. (2018). Five-year survival analysis of surgically resected gastric cancer cases in Japan: a retrospective analysis of more than 100,000 patients from the nationwide registry of the Japanese Gastric Cancer Association (2001–2007). Gastric cancer 21:144–154 The 15th Edition
9. Omloo JM, Lagarde SM, Hulscher JB et al (2007) Extended transthoracic resection compared with limited transhiatal resection for adenocarcinoma of the mid/distal esophagus: five-year survival of a randomized clinical trial. Ann Surg 246(6):992–1000
10. Wei MT, Zhang YC, Deng XB et al (2014) Transthoracic vs transhiatal surgery for cancer of the esophagogastric junction: a meta-analysis. World J Gastroenterol 20(29):10183–10192
11. Yan R, Dang C (2017) Meta-analysis of Transhiatal esophagectomy in carcinoma of esophagogastric junction, does it have an advantage? Int J Surg 42:183–190
12. Hager P, Blank S, Gooßen K et al (2019) Thoracoabdominal versus transhiatal surgical approaches for adenocarcinoma of the esophagogastric junction−a systematic review and meta-analysis. Langenbecks Arch Surg 404(1):103–113
13. Jezerskyte E, Mertens AC, Dieren SV et al (2022) Gastrectomy versus esophagectomy for gastroesophageal junction tumors: short- and long-term outcomes from the Dutch upper gastrointestinal cancer audit. Ann Surg 276(6):e735–e743

14. Sasako M, Sano T, Yamamoto S et al (2006) Left thoracoabdominal approach versus abdominal-transhiatal approach for gastric cancer of cardia or subcardia: a randomized controlled trial. Lancet Oncol 7(8):644–651
15. Kurokawa Y, Sasako M, Sano T et al (2015) Ten-year follow-up results of randomized trial comparing left thoracoabdominal and abdominal transhiatal approaches to total gastrectomy for adenocarcinoma of the oesophagogastric junction or gastric cardia. Br J Surg 102(4):341–348
16. Norero E, Quezada J, Cerda J et al (2019) Risk factors for severe postoperative complications after gastrectomy for gastric and esophagogastric junction cancers. Arq Bras Cir Dig 32(4):e1473
17. Tanaka Y, Kinoshita T, Akimoto E et al (2022) The impact of hiatal hernia on survival outcomes in patients with gastroesophageal junction adenocarcinoma. Ann Gastroenterol Surg 6(3):366–374
18. Mine S, Kurokawa Y, Takeuchi H et al (2022) Postoperative complications after a transthoracic esophagectomy or a transhiatal gastrectomy in patients with esophagogastric junctional cancers: a prospective nationwide multicenter study. Gastric Cancer 25(2):430–437
19. Jansen SM, de Bruin DM, van Berge Henegouwen MI et al (2021) Quantitative change of perfusion in gastric tube reconstruction by sidestream dark field microscopy (SDF) after esophagectomy, a prospective in-vivo cohort study. Eur J Surg Oncol 47(5):1034–1041
20. Fujioka M, Taniguchi K, Yoneda A et al (2023) Additional superdrainage reduces anastomotic fistula and stenosis after gastric tube reconstruction with cervical anastomosis for esophageal cancer. JTCVS Tech. https://doi.org/10.1016/j.xjtc.2023.03.005
21. Kono K, Sugai H, Omata H et al (2007) Transient bloodletting of the short gastric vein in the reconstructed gastric tube improves gastric microcirculation during esophagectomy. World J Surg 31:780–784
22. Kamarajah SK, Griffiths EA, Phillips AW et al (2022) Robotic techniques in esophagogastric cancer surgery: An assessment of short- and long-term clinical outcomes. Ann Surg Oncol 29(5):2812–2825
23. Kumamoto T, Ishida Y, Igeta M et al (2022) Potential advantages of robotic total gastrectomy for gastric cancer: a retrospective comparative cohort study. J Robot Surg 16(4):959–966
24. Alhossaini RM, Altamran AA, Seo WJ, Hyung WJ et al (2017) Robotic gastrectomy for gastric cancer: Current evidence. Ann Gastroenterol Surg 1(2):82–89